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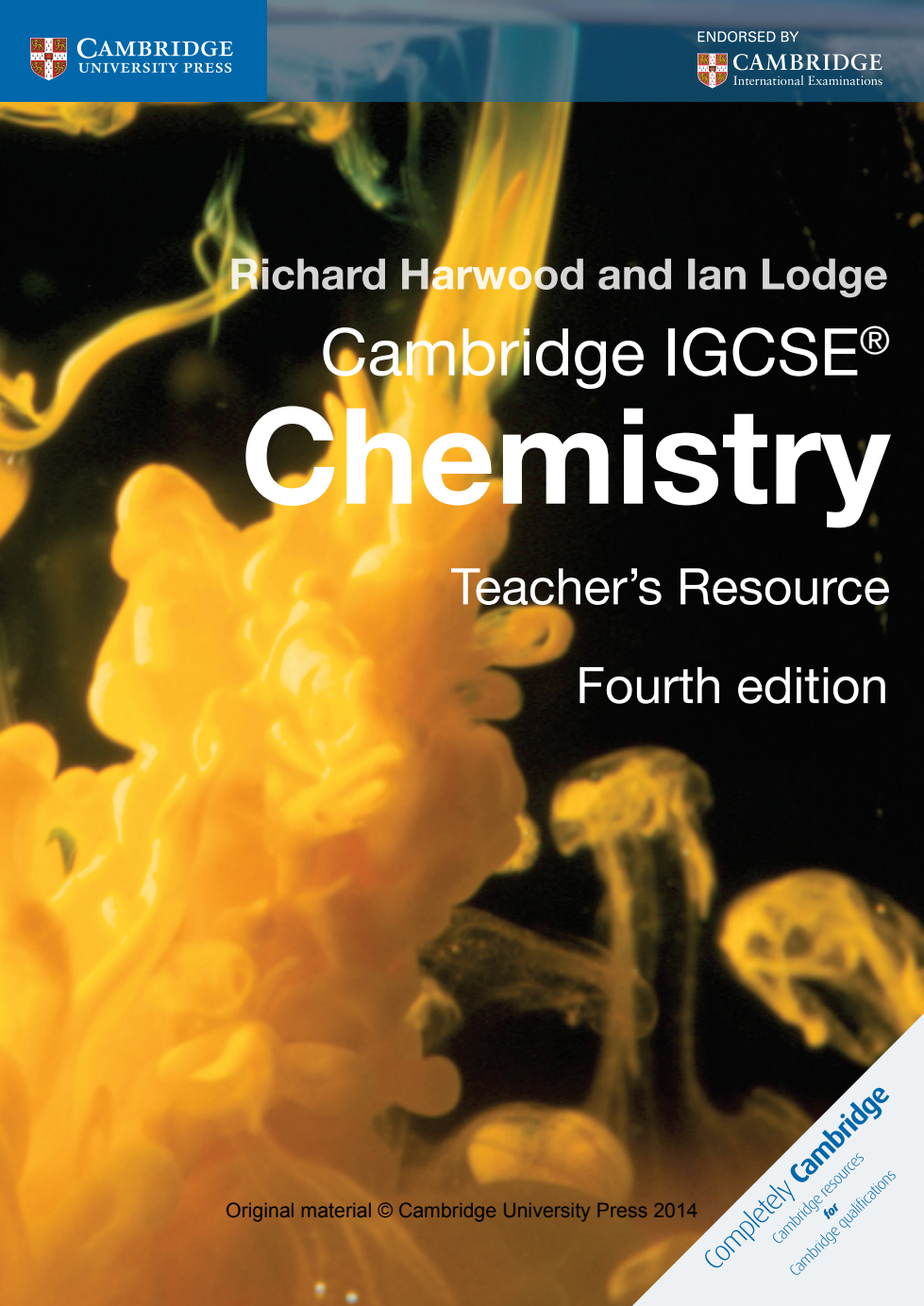
Cambridge IGCSE®
Chemistry

Teacher's Resource

Fourth edition



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Introduction to teaching ideas

The notes included here are intended to provide outline ideas for ways in which you might cover the Cambridge IGCSE Chemistry syllabus with your students. They are not intended to provide a scheme of work or lesson plans. There are several different ways in which the ideas and content of the syllabus can be covered, and the sequence and depth of treatment needs to be tailored to the students' prior experience and the school's context. Examples of schemes of work for this and similar courses can be found on the University of Cambridge International Examinations Teacher Support website (http://www.cie.org.uk/profiles/teachers). These schemes do suggest activities that can be used to teach various topics. Remember that a full scheme of work needs to be a 'living' document, continuously evaluated and modified as the course evolves.

Included on this resource, and on the Coursebook CD-ROM, are tables linking the chapter content of the Coursebook to the syllabus. However, it is most important to remember that chemistry is not just a body of knowledge to be learnt. The questions in the Coursebook, exercises in the Workbook and the worksheets supplied as part of this Teacher's Resource provide many opportunities for students to develop and assess their learning and familiarity with the subject. However, there are other skills which need to be developed throughout the course that relate to chemistry as a science. Students need to become familiar with scientific method. They should be asked to make careful observations and record them, to display, analyse and interpret results, to evaluate the reliability of results and to plan their own experiments. The content of the final chapter of the Coursebook, exercises in the Workbook and particularly the practical Activities featured in the Coursebook provide many opportunities for developing these skills, and you will certainly also like to add some of your own. Though not exhaustive, we have tried to suggest areas where ideas can be found. In particular, we have included some reference to the use of microscale chemistry and data-logging techniques, both areas that are developing rapidly worldwide. Throughout the Activities and Workbook Exercises we have suggested means for both student self-assessment and teacher evaluation of the development of various practical skills.

The notes for each chapter begin with a table suggesting a possible way of breaking up the material to be covered into a number of topics based on the different sections in each chapter. The number of periods suggested for each topic is probably a minimum, and most teachers are likely to want to spend more time than this on many topics. For each topic area, relevant resources in the Coursebook, Workbook and worksheets are listed together with external references to some useful websites. These websites are all active at the time of writing and likely to continue to be so. Outline descriptions of what might be included in each of these lessons are then given. These are no more than suggestions, and they are not comprehensive. You may like to use all of them, some of them or none of them! There is also a list of some of the most common student misunderstandings and misconceptions that are met in teaching the course, and some suggestions for tasks that could be set for homework. Revision checklists relating to the learning outcomes for each chapter, and to these teaching ideas, are provided on the Coursebook CD-ROM. Summaries linking the learning outcomes for each chapter to the sections of the syllabus they relate to are also included on this and the Coursebook CD-ROM.

Although the teaching ideas are grouped and ordered by chapter, it is not necessary for the sequence of concepts presented in the Coursebook to be followed exactly. Indeed, teachers are encouraged to present the topics in an order that they feel best suits their class. One possible different teaching sequence for the overall course is shown in Figure **1**. The sequence is depicted as a spiral to emphasise that certain topics build on others and the ideas can be revisited, introducing more complex ideas and examples, as the course progresses. The contents of the notes included are simply suggestions, some of which you might like to incorporate into your lessons.

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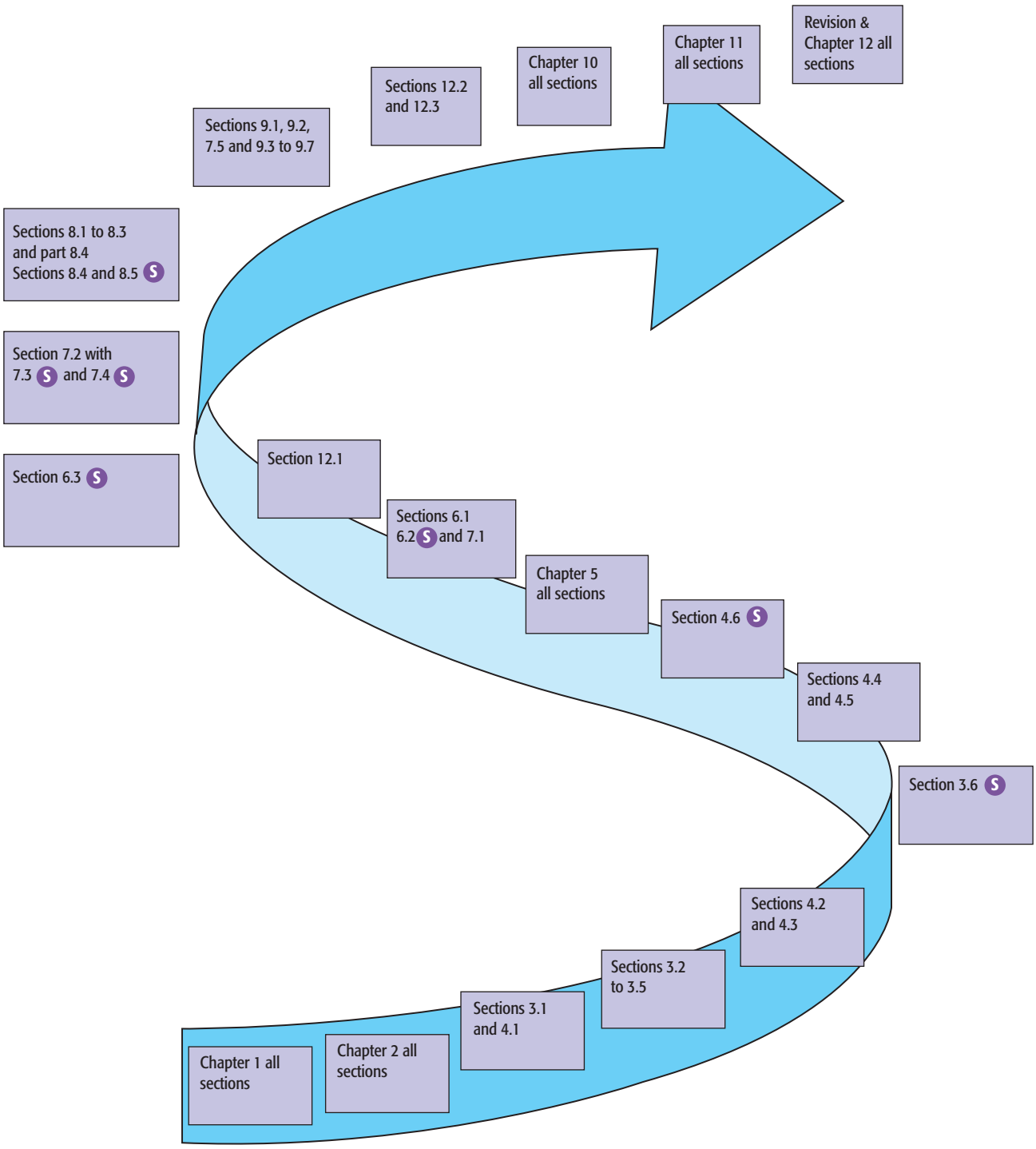
Revision & Chapter 12 all sections
Chapter 11 all sections
Chapter 10 all sections
Sections 12.2 and 12.3
Sections 9.1, 9.2, 7.5 and 9.3 to 9.7
Sections 8.1 to 8.3 and part 8.4
Sections 8.4 and 8.5 S
Section 7.2 with 7.3 S and 7.4 S
Section 6.3 S
Section 12.1
Sections 6.1 6.2 S and 7.1
Chapter 5 all sections
Section 4.6 S
Sections 4.4 and 4.5
Section 3.6 S
Sections 4.2 and 4.3
Sections 3.2 to 3.5
Sections 3.1 and 4.1
Chapter 2 all sections
Chapter 1 all sections

Figure 1 A possible teaching sequence for the course. The section numbers refer to the sections in the Coursebook. Suggestions for practical work related to these topics can be found in the teaching notes and the table of practical experiences included on this CD-ROM.

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Teaching ideas

Chapter 1 Planet Earth

Syllabus sections covered: Introduction; 6.2; 10.3; 11; 13; 14.2

Teaching resources

Syllabus section	Topic	40-minute periods	Resources in Coursebook	Resources in Workbook	Resources on this CD-ROM
11.4	Introduction: natural cycles and resources	3	Section 1.1 Questions 1.1 to 1.4 EOCQs 1, 6 Internet animations, linked from CD-ROM: The major natural cycles		Worksheet 1.1 What use is chemistry? Worksheet 1.5 The chemistry of the Earth's layers
11.2, 11.4 (7.2)	The atmosphere	4	Section 1.2 Activity 1.1 Estimating the amount of oxygen in air Questions 1.5 to 1.14 EOCQ 4 Animations on CD-ROM: Human activity and carbon dioxide; Acid rain; Review of chemistry of the air Internet animations, linked from CD-ROM: Human impact, resources and air pollution; Global warming and climate change; Acid rain	Exercise 1.1 Global warming and the 'greenhouse effect' Exercise 1.2 Atmospheric pollution, industry and transport Exercise 1.4 Gases in the air	Worksheet 1.2 Combustion Worksheet 1.4 What happened to all the carbon dioxide? Worksheet 1.6 Atmospheric anagrams Worksheet 1.7 Distillation of liquid air Worksheet 1.9 Catalysts in cars
11.1	Seas and rivers	2	Section 1.3 Activity 1.2 Chemicals from seawater Questions 1.15 to 1.19 EOCQs 2, 3	Exercise 1.3 Clean water is crucial	Worksheet 1.10 The acidification of the oceans

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Syllabus section	Topic	40-minute periods	Resources in Coursebook	Resources in Workbook	Resources on this CD-ROM
6.2, 10.3, 13, 14.2	The Earth's crust	3	Section 1.4 Activity 1.3 Thermal decomposition of calcium carbonate Activity 1.4 Hydrogen power – communicating the benefits Activity 1.5 Using solar and hydrogen power Questions 1.20 to 1.26 EOCQ 5 Animations on CD-ROM: Limestone from the ground; Using limestone	Exercise 1.5 Hydrogen as fuel Exercise 9.5 Concrete chemistry	Worksheet 1.3 Clean energy using hydrogen Worksheet 1.8 Fuel cells

Topic 1 Introduction: natural cycles and resources

Coursebook section 1.1 (pp. 1–5)

Teaching ideas

This first chapter serves to introduce the context in which chemistry studies have significance. The rules of chemistry are universal and relate to the existence of the Earth and many aspects of our lives on it. Worksheet 1.1 *What use is chemistry?* takes a different angle, emphasising how developments in chemistry impact our lives.

The 'cycles' of resources that take place are important, with the carbon cycle, the water cycle and the nitrogen cycle being the most significant from a syllabus point of view. Consideration of the cycles links to important ideas of chemical inter-conversion, changes of state and the nature of the resources of the Earth. Stress the important distinction between renewable and non-renewable resources.

Consideration of the carbon cycle is particularly important, with particular attention being given to the key reactions of photosynthesis and respiration and the part they play in maintaining the balance of the composition of the atmosphere – linking then into Topic 2. The demonstration of photosynthesis using *Elodea* (or some other oxygenating pond plant) could be effective here. For details of such an experiment see: http://www.practicalbiology.org/areas/intermediate/energy/photosynthesis/investigation

Common misunderstandings and misconceptions

This topic leads to very few misunderstandings – this is very much an introductory topic but it is useful to establish that the rules of chemistry are universal. For instance, the formula of water is the same wherever it is found – whether in the ice of the Antarctic or the rings of Saturn. Also it is useful to generate a balanced sense of the significance of chemistry in the modern world.

Homework ideas

- Worksheet 1.1 *What use is chemistry?*
- Worksheet 1.5 *The chemistry of the Earth's layers*

Topic 2 The atmosphere

Coursebook section 1.2 (pp. 5–10)

Teaching ideas

Describe the composition of clean, dry air. Discuss the origins and nature of various forms of atmospheric pollution, particularly acid rain and global warming. Describe the fractional distillation of liquid air.

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- Introduce the data on the composition of clean, dry air and ideas on the thin layer of atmosphere that covers the Earth's surface. The 'thinning' of the atmosphere with vertical height can be discussed and mention made of the ozone layer (though this environmental problem is not syllabus material). A comparison can be made with other, neighbouring, planets to introduce the significance of the presence of oxygen in the atmosphere. The maintenance of the levels of oxygen and carbon dioxide can be discussed in relation to photosynthesis and respiration. A practical demonstration of the estimation of the percentage of oxygen in the air by passing a sample of air repeatedly over heated copper turnings could be carried out (Activity 1.1 *Estimating the amount of oxygen in air*).
- Introduce the idea of atmospheric pollution using the examples of car exhaust gases and power stations.
- Discuss the different forms of pollution and their consequences – including acid rain and global warming. There are many useful websites, some of which are listed in the Coursebook CD-ROM, and the Royal Society of Chemistry (RSC) in the UK has produced a booklet of notes and activities on climate change which is very useful – *Climate Change* – and can be downloaded from the internet at http://www.rsc.org/Education/Teachers/ClimateChange/index.asp
- Discuss the effects of the various forms of atmospheric pollution and outline possible forms of remedial action, including the use of alternative energy technologies such as hydrogen power. This links to Topic 4 here.
- Discuss the fractional distillation of air to obtain samples of the gases.

Common misunderstandings and misconceptions

There are very few areas of misunderstanding in this topic. The major difficulty seems to be that, if the problems are not carefully distinguished, there is a general merging of the different environmental issues into one global 'mix' and students begin to get the ideas crossed in their minds. It is possibly worth breaking up the teaching of the topics to emphasise the distinctiveness of the issues. Linked to this is the problem of overexposure to these issues; with the topics being raised in a number of different subject areas, there is a risk of students becoming disinterested.

There is a case for some cross-curriculum collaboration on these issues within a school context.

Homework ideas

- Given the scope of material on the internet, there is potential for guided research drawing from defined websites to prepare for a class debate.
- Exercise 1.2 *Atmospheric pollution, industry and transport*
- Exercise 1.4 *Gases in the air*
- Worksheet 1.4 *What happened to all the carbon dioxide?*
- Worksheet 1.7 *Distillation of liquid air*
- Worksheet 1.9 *Catalysts in cars*
- Worksheet 1.2 *Combustion*
- Use Exercise 1.1 *Global warming and the 'greenhouse effect'* from the Workbook. This is a data-handling exercise and it can be extended from the manual drawing of the graphs to include the use of either Excel or 'Graphical Analysis' to plot and analyse the data. Further data and activities can be drawn from the RSC book *Climate Change*.

Topic 3 Seas and rivers

Coursebook section 1.3 (pp. 11–13)

Teaching ideas

Describe the processes involved in providing clean water for domestic and industrial use, and the subsequent treatment of sewage.

- Water is a key feature of the planet and its use as a resource is one of the key issues of the modern world, with pressure on the resource coming from pollution and the needs of the increasing world population for clean drinking water and sanitation. Discuss the water cycle and the methods currently used to purify water for domestic and industrial use, and the methods involved in sewage treatment. Discussion could extend to novel ways of desalination. The importance of a water supply for irrigation in agriculture should also be stressed.

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- Activity 1.2 *Chemicals from seawater* offers an opportunity to introduce some basic and standard practical techniques to the students (the need for this will depend on the prior experience of the students on earlier courses). It also links well with Worksheet 1.10 *The acidification of the oceans.*

Common misunderstandings and misconceptions

These areas surrounding water availability, pollution and the water cycle are relatively straightforward and provide a way into discussing both the broad issues of the provision of clean drinking water to populations and the basic ideas of the changes of state involved in the water cycle. The chemistry of the oceans also gives an entry into discussing solubilty, both of solids and gases.

Homework ideas

- Worksheet 1.10 *The acidification of the oceans*
- Exercise 1.3 *Clean water is crucial*

Topic 4 The Earth's crust

Coursebook section 1.4 (pp. 14–18)

Teaching ideas

Illustrate the usefulness of mineral resources by discussing the usefulness of limestone. Introduce hydrogen as an alternative source of energy for the future, including hydrogen fuel cells

- Limestone is a very useful mineral and it is used here as an example of a resource that can be quarried and processed to give useful products. The 'limestone cycle' is a useful introduction to some basic chemical ideas (Activity 1.3 *Thermal decomposition of calcium carbonate*).
- Activity 1.3 also offers an opportunity to introduce some basic and standard practical techniques to the students.
- The need for alternative energy sources has been touched on earlier and the 'hydrogen economy' offers one possible way ahead. The use of hydrogen to power cars raises some important introductory issues and again introduces some useful chemical ideas relating to exothermic reactions and the production of electrical energy from chemical reactions.
- Activity 1.4 *Hydrogen power – communicating the benefits* offers a good occasion to develop students' research and presentation skills in an area where some will have keen interest.
- Activity 1.5 *Using solar and hydrogen power* offers a novel introduction to electrochemistry and the power that is available form the reaction between hydrogen and oxygen. The demonstration can be made quite spectacular, and also the difference between generating electricity and using electricity to split compounds can be introduced.

Common misunderstandings and misconceptions

There are some cautions here in terms of the timing of the introduction of some aspects of the material. Both the treatment of limestone as a resource and hydrogen as a fuel are topics that will benefit from revisiting later in the course. It is suggested that any equations at the initial stages of these topics are restricted to word equations (depending, of course, on the prior experience of the students involved). Full chemical equations can be introduced when these topics are revisited. Note too that the syllabus specifically states that electrode equations for the hydrogen fuel cell are not required.

One other area where care is needed is the terminology involved in the limestone cycle. This involves some relatively old-style English vocabulary and it is worth being careful to define the terms limestone, lime (quicklime) and limewater clearly.

Homework ideas

- Use Activity 1.4 *Hydrogen power – communicating the benefits* as preparation for a class discussion/debate/presentation.
- Exercise 1.5 *Hydrogen as fuel*
- Worksheet 1.3 *Clean energy using hydrogen*
- Worksheet 1.8 *Fuel cells*

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Teaching ideas

Chapter 2 The nature of matter

Syllabus sections covered: 1; 2.2.1; 3.1; 3.2.1; 4.1

Teaching resources

Syllabus section	Topic	40-minute periods	Resources in Coursebook	Resources in Workbook	Resources on this CD-ROM
1	The states of matter	3	Section 2.1 Activity 2.1 Plotting a cooling curve Questions 2.1 to 2.5 EOCQs 1, 3	Exercise 2.1 Changing physical state Exercise 2.2 Plotting a cooling curve	Worksheet 2.1 States of matter Worksheet 2.3 States of matter and the kinetic theory
2.2.1; 3.2.1	Separating and purifying substances	4	Section 2.2 Activity 2.2 Separating common salt and sand Activity 2.3 Distillation of mixtures Activity 2.4 Investigation of food dyes by chromatography Questions 2.6 to 2.10 EOCQ 4 Animations on CD-ROM: Identifying colours	Exercise 2.4 Chromatography at the races	Worksheet 2.2 Separating mixtures Worksheet 2.6 Solubility rules!
1; 3.1, 4.1	Atoms and molecules	4	Section 2.3 Activity 2.5 Investigating diffusion – a demonstration Questions 2.11 to 2.15 EOCQs 2, 5, 8 Animations on CD-ROM: What is an element?; Which element?; Symbols; What is a compound?; Element or compound? Internet animations, linked from CD-ROM: Kinetic theory and diffusion	Exercise 2.3 Diffusion, solubility and separation	Worksheet 2.5 The motion of particles

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Syllabus section	Topic	40-minute periods	Resources in Coursebook	Resources in Workbook	Resources on this CD-ROM
3.1	The structure of the atom	2	Section 2.4 Activity 2.6 Discovering the structure of the atom Questions 2.16 to 2.19 EOCQ 6 Internet animations, linked from CD-ROM: Atomic structure and isotopes	Exercise 2.5 Atomic structure	Worksheet 2.4 Atomic structure
3.1	Electron arrangements in atoms	2	Section 2.5 Questions 2.20 to 2.23 EOCQ 7	Exercise 2.6 Influential organisation	

Topic 1 The states of matter

Coursebook section 2.1 (pp. 21–27)

Teaching ideas

This is an introduction to the states of matter, changes of state and the terminology involved.

- Introduce the different states of matter – can relate back to the Earth as seen from space ('the blue marble'), the one planet in the solar system where water exists in all three different states simultaneously. Emphasise the terminology involved, the bulk properties of the different states and that changes in state can be brought about by change in temperature or pressure (or a combination of the two).
- Demonstrate some changes of state, such as gallium melting in the hand (if available) or the sublimation of iodine or of dry ice (solid carbon dioxide). Use a carbon dioxide fire extinguisher (if a suitable one is available) to show that carbon dioxide can exist as a liquid at room temperature when under pressure.
- Construct a cooling curve (Activity 2.1 *Plotting a cooling curve*) as a class experiment. Note that this can be adapted as a very useful introductory demonstration of data logging with the results 'screened' as the experiment progresses.

Common misunderstandings and misconceptions

There is little conceptual difficulty here but care must be taken because students tend to forget that a change of state can be brought about by a change of pressure (with the temperature remaining constant). They also sometimes have difficulty with the idea that any substance can exist in any of the three states depending on the conditions, so it is worthwhile emphasising this with examples. Even the extreme case of hydrogen being a solid at the core of the 'gas giants' Jupiter and Saturn can be helpful here.

Homework ideas

- Coursebook questions 2.1 to 2.5 and End-of-chapter questions 1 and 3
- Worksheet 2.1 *States of matter*
- Exercise 2.1 *Changing physical state*
- The writing of a report and processing of results from Activity 2.1 *Plotting a cooling curve* can be a homework exercise. In addition, Exercise 2.2 *Plotting a cooling curve* deals with the processing and evaluation of such results.
- The explanation of changes of state in terms of the kinetic theory is explored in Worksheet 2.3 *States of matter and the kinetic theory.*

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Topic 2 Separating and purifying substances

Coursebook section 2.2 (pp. 27–34)

Teaching ideas

Introduce various methods of separation based on physical properties. Discuss the ideas of chemical purity, including chromatography.

- Introduce the idea that differences in a physical property can be used to separate substances from each other. There is a range of practical activities that can be carried out: Activity 2.2 *Separating common salt sand;* Activity 2.3 *Distillation of mixtures;* Activity 2.4 *Investigation of food dyes by chromatography*. The activity on distillation here is carried out using microscale apparatus, but it would be worthwhile for students to see the full-scale apparatus for simple and fractional distillation demonstrated. Similarly, a demonstration of the use of a separating funnel could be carried out.
- The ideas of chemical purity should be explored, with reference to the ideas of boiling point and melting point precision and chromatography as useful indicators of purity. Chromatography of food dyes or simple inks can be successfully carried out, while non-permanent felt-tipped pens also work well. The use of R_f values to analyse the height of the spots on the chromatogram can be practised with students taking the extended papers.
- The separation of amino acids by chromatography and the use of locating agents are described in Activity 11.6 *Chromatography of amino acids* but, while the possibility of such separations can be mentioned here, it would seem more appropriate to carry out this activity later in the course, in the context of proteins and other condensation polymers.
- The effect of an impurity on the boiling point or melting point of a substance can be demonstrated by using water and dissolving sodium chloride or other salts in it.
- The concept of elements and compounds should be introduced here together with the idea of chemical symbols for the elements. The determination of the melting point of a solid could be demonstrated.
- Some of the separations usefully employed in this context could be presented to the students as 'challenges' – for example, show students a mixture of sand and salt and challenge them to think of ways to separate these; they could be challenged to suggest solvents that could be used to remove ink (both water-soluble and permanent) from a plastic surface, or nail varnish painted on to a glass microscope slide.

Common misunderstandings and misconceptions

The content of this topic is relatively practical. As such, there are very few difficulties with the ideas involved, provided students are given particular and relevant examples of the diff erent types of separation and their purpose.

Homework ideas

- Coursebook questions 2.6 to 2.10 and End-of-chapter question 4
- Worksheet 2.2 *Separating mixtures*
- The use of chromatography in analysing mixtures is dealt with in Exercise 2.4 *Chromatography at the races*.
- Worksheet 2.6 *Solubility rules!* is a predominantly data-handling exercise exploring the interpretation of graphs and the manipulation of concentration data. This could be given as homework at a time when the simple practical on the solubility of gases is carried out.

Topic 3 Atoms and molecules

Coursebook section 2.3 (pp. 34–40)

Teaching ideas

Explain the different states of matter in terms of the movement of particles. Introduce the idea of atoms the concept of elements and compounds.

- Here the concept of all matter being made up of incredibly small particles is developed, with the ideas of atoms and molecules being developed further. The motion of the particles in the different states of matter is explored. It is important to stress the difference in organisation and particle movement between the three states, with the

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interpretation of diagrams illustrating the three states being key. Use 'particles in boxes' diagrams to represent the three states of matter and stress the importance of the changes in arrangement and range of movement between states.

- The concept of the kinetic theory is used to explain how changes of state happen. The role of energy changes is of crucial importance when discussing the making, or breaking, of forces of attraction between particles. This discussion should be related back to the cooling curve experiment carried out earlier.
- The process of diffusion – the spreading of particles throughout a fluid state – should be discussed. Activity 2.5 *Investigating diffusion* using ammonia and hydrogen chloride gases can be carried out by students using microscale apparatus, but they should also see a normal scale demonstration of this classic experiment. The accompanying example of diffusion in liquids is an impressive and eye-catching experiment that can be readily carried out by students themselves.
- Other simple examples of diffusion that can be used include perfume smells, the movement of nitrogen dioxide gas or bromine vapour and coloured inks in water. Air freshener sprayed on a watch glass on the back of a student's hand can be used. The student can describe the changes seen (and felt) while other students indicate when the smell has reached them in the room. Tea bags held by a glass rod in beakers of hot and cold water demonstrate the changing rate of diffusion with temperature.
- The motion of sub-microscopic particles is demonstrated by Brownian motion, and this can be shown under the microscope using a smoke cell (for the gas phase) or *Lycopodium* powder sprinkled on the surface of water.
- This CD-ROM and the Coursebook CD-ROM have a reference to a website showing images of atoms produced by a scanning tunnelling microscope. These images are useful in giving a 'picture' of the hitherto sub-microscopic and generate interest among students.

Common misunderstandings and misconceptions

One practical mistake that students often make in their diagrams is drawing the particles in a liquid too far apart. It is worth remembering that, although they can move laterally, the particles in a liquid are close together.

The major conceptual problem in this context is in dealing with the sub-microscopic and having a sense of what is happening at that level. That is why any means of visualising what is happening is useful. The American Chemical Society has recently published a series of animations dealing with changes of state. They are part of their 'Inquiry in Action' publication (www.inquiryinaction.org/) and are freely accessible and downloadable. They deal with the different states of matter, and with the processes involved in dissolving and can be accessed at the following addresses:

http://www.inquiryinaction.org/chemistryreview/solids/
http://www.inquiryinaction.org/chemistryreview/liquids/
http://www.inquiryinaction.org/chemistryreview/dissolving/
http://www.inquiryinaction.org/chemistryreview/states_of_matter/

The demonstration of Brownian motion can be impressive and is historically significant (and Einstein wrote his first paper on this subject). However, students can have difficulty with the idea of the secondary motion of the observed particles being a consequence of the movement of other 'unseen' particles.

Homework ideas

- Coursebook questions 2.11 to 2.15 and End-of-chapter questions 2, 5 and 8
- Worksheet 2.5 *The motion of particles* deals with the observation of Brownian motion, which is new to the syllabus.
- Exercise 2.3 *Diffusion, solubility and separation* from the Workbook deals with these basic phenomena that gave the initial suggestions of the particulate nature of matter.
- Students could be asked for a written report on Activity 2.5 *Investigating diffusion*, including the answers to the question on that practical activity sheet.

Topic 4 The structure of the atom

Coursebook section 2.4 (pp. 41–47)

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Teaching ideas

Discuss the structure of the atom in terms of a nucleus surrounded by orbiting electrons. Introduce the different subatomic particles and the idea of isotopes.

- The aim here is to generate familiarity with the subatomic structure of the atom and the nature of the three subatomic particles specified in the syllabus. The model of the atom we are using is that of a central nucleus with electrons orbiting at different energy levels (shells).
- Introduce the different subatomic particles in terms of their relative mass, relative electrical charge and location in the atom. The two major numbers – proton number and nucleon number – that specify the composition of any atom will need to be defined. Stress that, since an atom is electrically neutral, the proton number (or atomic number) is also the number of electrons in an atom. It is also worth emphasising that it represents the position of that element in the Periodic Table. The existence of isotopes needs to be introduced, focusing on the chemical similarity but mass differences between the atoms of the same element. Radioactivity is touched on in only a limited way, but students do need to know a medical and industrial use of radioisotopes and the use of uranium in power stations.
- Discuss how the electrons are organised in the atom and focus on the first 20 elements (to calcium) as the atoms students will be asked to describe in the examination. Begin to explain the link between electron arrangement and position in the Periodic Table in preparation for the next chapter.

Common misunderstandings and misconceptions

The difficulties here again stem from the visualisation of phenomena that are sub-microscopic. For that reason, the website listed on this and the Coursebook CD-ROM in the 'Animations' section is helpful for demonstrating the structure of the atom. This site describes the original Geiger–Marsden experiment on the structure of the atom.

Homework ideas

- Coursebook questions 2.16 to 2.19 and End-of-chapter question 6
- Exercise 2.5 *Atomic structure*
- Worksheet 2.4 *Atomic structure*
- Activity 2.6 *Discovering the structure of the atom* is a web-based investigation into the significant historical developments that led to the modern model of atomic structure and could be the basis for a follow-up class discussion.

Topic 5 Electron arrangements in atoms

Coursebook section 2.5 (pp. 47–48)

Teaching ideas

Discuss how the electrons are organised in the atom and focus on the first 20 elements (to calcium) as the atoms students will be asked to describe in the examination. Begin to explain the link between electron arrangement and position in the Periodic Table in preparation for the next chapter.

Common misunderstandings and misconceptions

Students will arrive with widely different exposure to ideas of the atom – some international students will come with prior knowledge of the s, p, d, f model of electron arrangement and will have to adapt to working with the simpler model for the time being. One idea which can confuse students is the notion of 'full' outer shells. This is difficult when, in fact, the third shell can take up to 18 electrons, for instance. Where possible, it is best to avoid the word 'full' and rather talk of 'stable arrangements' of electrons.

Homework ideas

- Coursebook questions 2.20 to 2.23 and End-of-chapter question 7
- Exercise 2.6 *Influential organisation* in the Workbook asks students questions about the organisation of the atom within the context of the historically significant Geiger–Marsden experiment.

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Teaching ideas

Chapter 3 Elements and compounds

Syllabus sections covered: 3.2; 4.1; 9

Teaching resources

Syllabus section	Topic	40-minute periods	Resources in Coursebook	Resources in Workbook	Resources on this CD-ROM
9.1	The Periodic Table – classifying the elements	1	Section 3.1 Activity 3.1 Testing metals and non-metals Questions 3.1 to 3.5 EOCQs 1, 2 Animations on CD-ROM: Noble gases. Internet animations, linked from CD-ROM: The Periodic Table	Exercise 3.1 Periodic patterns in the properties of the elements Exercise 3.2 The first four periods	Worksheet 3.1 Mind-mapping the Periodic Table Worksheet 3.2 Patterns in the Periodic Table Worksheet 3.6 Periodic Table crossword Worksheet 3.8 The Periodic Table of the elements
9.3; 9.5	Trends in groups	3	Section 3.2 Questions 3.6 to 3.9 EOCQ 3 Internet animations, linked from CD-ROM: The elements and their groups	Exercise 3.3 Trends in the halogens	Worksheet 3.9 Noble and inert! Worksheet 3.11 Properties of the noble gases Worksheet 3.13 The Periodic Table: the halogens Video clips on the reactivity of the alkali metals
9.2	Trends across a period	2	Section 3.3 Questions 3.10 to 3.15 EOCQ 4		Worksheet 3.7 Trends in the Periodic Table Worksheet 3.12 The third period Worksheet 3.14 Mid-table elements

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Syllabus section	Topic	40-minute periods	Resources in Coursebook	Resources in Workbook	Resources on this CD-ROM
3.2	Chemical bonding in elements and compounds	6	Section 3.4 Activity 3.2 Boiling water in a cup of ice! Activity 3.3 Modelling the bonding in covalent substances Questions 3.16 to 3.22 EOCQs 5, 6 Internet animations, linked from CD-ROM: Ions and ionic bonding; Covalent bonding; Metallic bonding	Exercise 3.4 The chemical bonding in simple molecules Exercise 3.6 The bonding in covalent molecules	Worksheet 3.3 Chemical bonding Worksheet 3.10 Ionic crystals
4.2	The chemical formulae of elements and compounds	4	Section 3.5 Questions 3.23 to 3.26	Exercise 3.5 Formulae of ionic compounds Exercise 3.9 Making magnesium oxide – a quantitative investigation	Worksheet 3.4 Writing chemical formulae Worksheet 3.15 Formulae of ionic compounds Worksheet 4.6 Chemical mnemonics
3.2	Metals, alloys and crystals	4	Section 3.6 Activity 3.4 Modelling metallic crystal structure Activity 3.5 Intriguing alloys! Questions 3.27 to 3.33 Animations on CD-ROM: Where do we find metals?; What is an alloy?; How do we make an alloy?	Exercise 3.7 The nature of ionic lattices Exercise 3.8 Giant molecular lattices	Worksheet 3.5 Bonding and crystal structure

Topic 1 The Periodic Table – classifying the elements

Coursebook section 3.1 (pp. 55–60)

Teaching ideas

Discuss the characteristic structure of the table – the idea of periodic variation in properties among the elements – division into groups and periods. Outline the nature of an element and the distinction between metals and non-metals.

- Introduce the students to the concept of 'elements' by exploring the ideas they have from earlier science courses – use of the Discovery Channel video 'The Elements' featuring the English modern poet Roger McGough can generate great interest, as can playing the 'Elements Song' by Tom Lehrer.
- Begin to introduce the idea of classifying the elements by discussing the differences between metals and non-metals. Stress the use of testing electrical conductivity as the method of choice for distinguishing metals from non-metals (see Activity 3.1 *Testing metals and non-metals*).

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- Link the arrangement of the elements in the Periodic Table to atomic size/structure, moving from the lightest element, hydrogen, to the heavier elements. Note that the elements in the lower part of the table are man-made. Stress the universality of the Periodic Table – these are the elements that make up the Universe.
- Draw on the ideas that helped Mendeleev construct his initial Periodic Table – that the elements can be grouped further according to physical and chemical properties, and that this can be related to electron arrangement. Introduce the three main groups that the students will need to refer to – the alkali metals, the halogens and the noble gases – and the transition metals.
- Make use of the interactive and informative Periodic Tables that are available on the internet and referred to on this and the Coursebook CD-ROM.

Common misunderstandings and misconceptions

This topic leads to very few misunderstandings, although be careful with alloys (steel, for example) which, although, metallic are not individual elements but mixtures of metals with other elements. Stress the importance of the outer electrons in determining which group an element is in, rather than becoming involved in the complexities of the electron arrangements of the elements lower in the Periodic Table. Emphasise that groups run vertically, whereas periods run horizontally.

Homework ideas

- Carry out written project work on an element – or group of elements – using the interactive and informative Periodic Tables that are available on the internet and referred to on this and the Coursebook CD-ROM (see 'Animations' section).
- The Visual Elements Periodic Table on the Royal Society of Chemistry website (UK) (www.rsc.org) has artistic representations of the periodic variation of various properties of the elements across and through the table.
- Carry out the Workbook Exercise 3.1 *Periodic patterns in the properties of the elements* and link this to Worksheet 3.2 *Patterns in the Periodic Table*.
- Use Worksheet 3.1 *Mind mapping the Periodic Table* to help develop the students' ideas regarding the Periodic Table – this can be done as a group exercise.
- Worksheet 3.8 *The Periodic Table of the elements* provides an angle on the history of the development of the table, while Exercise 3.2 *The first four periods* introduces further the idea of patterns in the table.
- Coursebook questions 3.1 to 3.5 could be used, as could End-of-chapter questions 1 and 2.
- Worksheet 3.6 *Periodic Table crossword* is provided as a gentle revision aid.

Topic 2 Trends in groups

Coursebook section 3.2 (pp. 60–63)

Teaching ideas

This topic discusses the reactivity in groups – metals and non-metals.

- Introduce the trends in the Periodic Table – the horizontal transition from metal to non-metal, and the vertical trends in reactivity that result in the diagonal pattern of reactivity across the table.
- Certain groups are key to the discussion from a syllabus point of view, with the alkali metals and the halogens being the most important in illustrating the trends down a metallic and non-metallic group. The reactivity of the alkali metals should be demonstrated to the class, pointing out the progression in reactivity, the nature of the gas given off and the alkaline nature of the solution produced. The displacement reactions of the halogens can be used as a class experiment.
- The noble gases and the general properties of the transition metals should also be discussed. The trends and characteristic properties of these groups should be used to encourage the skills of the students in the prediction of the properties of unfamiliar elements.

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Common misunderstandings and misconceptions

There are few conceptual difficulties with the ideas involved in this topic. The important aspect is to remember the opposite trends in reactivity that occur in metal and non-metal groups. The other important aspect to emphasise to the students is that they need to be confident in extrapolating information from examples that they know to less familiar situations and also to be able to discuss trends in properties clearly.

Homework ideas

- Use Exercise 3.3 *Trends in the halogens* from the Workbook to illustrate the gradation of properties in Group VII, an area also covered in Worksheet 3.13 *The Periodic Table: the halogens*.
- Complete Worksheet 3.9 *Noble and inert!* and Worksheet 3.11 *Properties of the noble gases* to examine the properties of Group 0 elements.
- Coursebook questions 3.6 to 3.9 could be used, as could End-of-chapter question 3.
- Write up a summary of a demonstration on reactivity of the alkali metals using appropriate table(s) and giving word equations for the reactions observed.

Topic 3 Trends across a period

Coursebook section 3.3 (pp. 63–65)

Teaching ideas

Introduce a further trend in the Periodic Table – the horizontal transition from metal to non-metal, which, with the vertical trends in reactivity, result in the diagonal pattern of properties across the table. Note particularly the stepped line marking the division between metal and non-metal and the transition in the type of bonding in the elements.

Common misunderstandings and misconceptions

Students tend to view the division between metal and non-metal too rigidly. It is worth discussing the gradation in properties – with aluminium being a useful element to mention here.

Homework ideas

- The trends across the Periodic Table are covered in Worksheet 3.7 *Trends in the Periodic Table* and Worksheet 3.12 *The third period*.
- Worksheet 3.14 *Mid-table elements*
- Coursebook questions 3.10 to 3.15 and End-of-chapter question 4

Topic 4 Chemical bonding in elements and compounds

Coursebook section 3.4 (pp. 65–75)

Teaching ideas

Introduce the different types of chemical bonding and the involvement of electrons in forming the bonds.

- The essential point here is to maintain a clear distinction between the different types of bonding that can exist between atoms. One approach is to begin with the bonding in the structures adopted by the elements, relating this to the position of the element in the Periodic Table and hence drawing on the major distinction between the metals and non-metals.
- The discussion of metallic bonding can be reasonably brief and focus on a description of metal ions arranged in a lattice surrounded by mobile electrons. Link these ideas to the characteristic physical properties shown by metals; electrical and thermal conductivity, malleability etc.
- Much more detail is required when discussing the formation of covalent bonds in simple molecules such as hydrogen and chlorine. The concept of a single covalent bond as a shared pair of electrons is crucial. The discussion of the elements does allow for the introduction of the idea of multiple covalent bonds.
- Having discussed the simple molecules of the elements, it is then possible to move on to simple molecular compounds and illustrate how these are formed. The use of molecular models is important here in helping students visualise the structures formed. Giant covalent structures can be introduced at this stage but can be returned to at a later date.

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- The distinction that is clear at this level is that covalent bonding is involved in the formation of molecules consisting of non-metal atoms. Compounds that contain a metal use a different form of bonding – ionic bonding.
- The discussion of ionic bonding again flows from examining the bonding of simple binary compounds then progressing on to more complex examples, including those involving compound ions. The idea of balancing the charges so that there is no overall charge on the formula is important to enable students to arrive at the correct combinations of ions in a compound.

Common misunderstandings and misconceptions

This topic covers some complex ideas, particularly as the phenomena discussed are taking place at a sub-microscopic level and can be difficult to visualise. The use of, and familiarity with, key types of diagram are crucial here and it is worth practising these to develop real familiarity. Similarly, molecular models (see Activity 3.3 *Modelling the bonding in covalent substances*) and the simulations available on the internet are very useful for illustrating the concepts of electron sharing or transfer that are key to understanding here. A list of appropriate websites is given on this and the Coursebook CD-ROM in the 'Animations' section.

Homework ideas

- Exercise 3.4 *The chemical bonding in simple molecules* and Exercise 3.6 *The bonding in covalent molecules*
- Worksheet 3.3 *Chemical bonding* and Worksheet 3.10 *Ionic crystals* cover the two major types of bonding in compounds.
- Coursebook questions 3.16 to 3.22 and End-of-chapter questions 5 and 6

Topic 5 The chemical formulae of elements and compounds

Coursebook section 3.5 (pp. 75–78)

Teaching ideas

Introduce the idea of valency and the writing of chemical formulae.

- The idea of 'combining power' or valency can be a useful one to stress since it can be applied without reference necessarily to the type of bonding present in a compound – it can simply be regarded as the number of bonds an atom can form and used as that in the manner described in the Coursebook. The application of this idea is then practised through a good number of examples to reinforce the idea.
- The link between valency and position in the Periodic Table is a very useful one because it gives the student a means of remembering the numbers involved.
- Once confidence has been gained, a more detailed approach can fill in the difference in meaning of the concept of 'combining power' for metals and non-metals where they participate in the different types of bonding – ionic or covalent.
- There are some features of this area that simply must be learnt by the student, such as the fact that certain elements exist naturally as diatomic molecules and the formulae of certain compound ions (see Worksheet 4.6 *Chemical mnemonics* for a useful mnemonic for remembering these diatomic elements).

Common misunderstandings and misconceptions

This is a complex area for some students and there are visual aids – involving cards for the different elements and groups that are shaped like jigsaw pieces – that are aimed at giving some students a practical way of 'seeing' how the fit between atoms works. For some, simply working at a pragmatic level using numbers that 'cross over' is sufficient for their needs, but other students are helped if the method can be rationalised and explained in terms of electron pairing and ionic charge.

Homework ideas

- Exercise 3.9 *Making magnesium oxide – a quantitative investigation* from the Workbook gives a perspective on how formulae were originally established from practical data.

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- Complete Worksheet 3.4 *Writing chemical formulae* and Worksheet 3.15 *Formulae of ionic compounds* for practice at working out formulae. Further examples for practice can be found in the Workbook in Exercise 3.5 *Formulae of ionic compounds*.
- Coursebook questions 3.23 to 3.26 are also useful as an exercise.

Topic 6 Metals, alloys and crystals

Coursebook section 3.6 (pp. 78–85)

Teaching ideas

Discuss the structure of metallic, ionic and giant covalent crystals, including alloys.

- The discussion here needs to be clearly delineated into the various types of structure so that the distinctive features of the structures are clearly linked to the physical properties exhibited by clear-cut examples of the lattice types. Models of the different lattice types are particularly useful here in emphasising the differences between the structures and the link to properties.
- The representation of the different lattice types in diagrams is important here as students need to be able to recognise the different structures. There are certain key examples that should be highlighted in this context – the structure of an alloy, the different structures of diamond and graphite and the similarity of the silicon(IV) oxide structure to diamond being the most significant. Activity 3.4 *Modelling metallic crystal structure* and Activity 3.5 *Intriguing alloys!* are useful in giving an idea of the structure of metal lattices and the manipulation of properties that lies behind the devising of alloys.

Common misunderstandings and misconceptions

Provided there is visual support to aid the discussion of these different types of structure, there are few conceptual difficulties with this topic. The link between structure and physical properties is very helpful in reinforcing the distinction between the types of crystal lattice.

Homework ideas

- Exercise 3.7 *The nature of ionic lattices* and *Exercise 3.8 Giant molecular lattices*
- *Worksheet 3.5 Bonding and crystal structure*
- Coursebook questions 3.27 to 3.33

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Teaching ideas

Chapter 4 Chemical reactions

Syllabus sections covered: 7.1; 4.1; 5; 7.4; 10.3

Teaching resources

Syllabus section	Topic	40-minute periods	Resources in Coursebook	Resources in Workbook	Resources on this CD-ROM
7.1; 4.1	Chemical reactions and equations	1	Section 4.1 Questions 4.1 to 4.3 EOCQ 1 Internet animations, linked from CD-ROM: Chemical reactions	Exercise 4.1 Key chemical reactions	Worksheet 4.1 Recognising chemical reactions Worksheet 4.6 Chemical mnemonics
4.1	Equations for chemical reactions	2	Section 4.2 Questions 4.4 to 4.5 Internet animation, linked from CD-ROM: Balancing chemical equations		Worksheet 4.2 Balancing chemical equations
7.4	Types of chemical reaction	4	Section 4.3 Questions 4.6 to 4.8 EOCQs 2, 3, 4, 7	Exercise 4.2 The action of heat on metal carbonates Exercise 4.4 Displacement reactions of the halogens Exercise 4.5 Self-heating cans, hand warmers and cool packs	Worksheet 4.3 Different types of chemical reaction Worksheet 4.5 Film chemistry Worksheet 4.8 Types of reaction
7.4	A closer look at reactions, particularly redox reactions	2	Section 4.4 Questions 4.9 to 4.10		Worksheet 4.7 Important redox reactions
5	Electrolysis	4	Section 4.5 Activity 4.1 The conductivity of liquids and aqueous solutions Activity 4.2 Web researching the extraction of aluminium Questions 4.11 to 4.14 EOCQ 5 Internet animations, linked from CD-ROM: Electrolysis	Exercise 4.3 The nature of electrolysis Exercise 4.6 The movement of ions Exercise 4.7 Making and 'breaking' copper chloride	

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Syllabus section	Topic	40-minute periods	Resources in Coursebook	Resources in Workbook	Resources on this CD-ROM
5	A closer look at electrode reactions	1	Section 4.6 Activity 4.3 The electrolysis of concentrated sodium chloride solution Activity 4.4 Electroplating copper with nickel Activity 4.5 Electrolysis of copper(II) sulfate solution Questions 4.15 to 4.16 EOCQ 6		Worksheet 4.4 A colourful electrolysis – demonstration

Topic 1 Chemical reactions and equations

Coursebook section 4.1 (pp. 89–91)

Teaching ideas

This is an introduction to the idea of chemical change – new substances being made – in contrast to a physical change.

- The focus of this introductory session is simply the key aspect of chemical reactions: namely, that new substance(s) are formed. The distinction is with physical changes where, no matter how spectacular, the substances involved remain unchanged.
- It is possible to move on from this first point to begin to discuss the idea that atoms are simply 'changing partners' in a chemical reaction – old arrangements are being broken down and new combinations established.

Common misunderstandings and misconceptions

There are few misconceptions here, although particular examples may be misinterpreted and need explanation.

Homework ideas

- Worksheet 4.1 *Recognising chemical reactions*
- Exercise 4.1 *Key chemical reactions*
- Coursebook questions 4.1 to 4.3 and End-of-chapter question 1 are useful in this context.
- Worksheet 4.6 *Chemical mnemonics* gives some useful ways of remembering key ideas.

Topic 2 Equations for chemical reactions

Coursebook section 4.2 (pp. 91–94)

Teaching ideas

Introduce the concept of the law of conservation of mass – in a reaction atoms are simply changing the way in which they are combined – balancing equations. An equation is presented as a summary of a chemical change.

- The aim here is to introduce the two forms of equation that students will encounter on this course. Both build on the key ideas introduced earlier. Word equations stem from the idea of the elements/compounds present in a reaction mixture recombining to form new substances. Balanced chemical equations develop this further in that the elements present and their recombination are clearly evident in the formulae involved.
- The concept of balancing stems from the need to account for all of the atoms involved. Diagrams and/or molecular models can helpfully be used to visualise the changes taking place. The approach that seems most successful here is that of progressive repetition, with the examples involved developing in complexity with time. The terminology of reactants and products also needs to be introduced, but that is straightforward compared with some of the more complex examples of balancing.

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Common misunderstandings and misconceptions

Although the basic understanding of a chemical reaction may be relatively straightforward, as is the use of word equations, the technique of balancing equations proves problematic for some students. As mentioned earlier, the key is to develop some confidence in handling some of the less complex examples before building up the level of difficulty.

Homework ideas

- Worksheet 4.2 *Balancing chemical equations*
- Coursebook questions 4.4 and 4.5

Topic 3 Types of chemical reaction

Coursebook section 4.3 (pp. 94–99)

Teaching ideas

Survey the important types of chemical reaction. Define redox in terms of oxygen transfer. Discuss the further definitions of redox reactions.

- The aim here is to demonstrate, or get the students to carry out, some of the different types of chemical reaction. This can be made quite interesting to the students and can be used to intersperse the 'theoretical' treatment of the work on chemical equations.
- The key types of reaction can all be introduced but some focus is placed on the important topic of the different definitions of oxidation and reduction; focus here on the definition in terms of oxygen loss or gain. Again, there is good scope for practical examples to help reinforce the ideas. The terms 'oxidising agent' and 'reducing agent' need to be carefully introduced alongside the idea of an overall redox reaction.

Common misunderstandings and misconceptions

Most of the definitions for the different reaction types are clear-cut, even allowing for the fact that some reactions can fall into several categories. The most complex ideas here relate to the definitions of oxidation–reduction and the use of the terms 'oxidising agent' and 'reducing agent'.

Homework ideas

- Worksheet 4.3 *Different types of chemical reaction* and Worksheet 4.8 *Types of chemical reaction*
- Exercise 4.2 *The action of heat on carbonates* and Exercise 4.4 *Displacement reactions of the halogens*
- Questions 4.6 to 4.8 and End-of-chapter questions 2, 3, 4 and 7 from the Coursebook are useful in this context.
- The photochemical reactions of silver halides are discussed in Worksheet 4.5 *Film chemistry* while Exercise 4.5 *Self-heating cans, hand warmers and cool packs* shows some novel uses of chemical reactions.

Topic 4 A closer look at reactions, particularly redox reactions

Coursebook section 4.4 (pp. 100–102)

Teaching ideas

- Extend the definition of redox to include the loss or gain of electrons and change in oxidation state. The use of the mnemonic 'oil rig' is clearly of benefit.
- The use of oxidation state here is quite limited but relevant to the naming of various compounds.
- Include in your discussion the tests for, and definitions of, oxidising and reducing agents.
- The displacement reactions of the halogens are useful here, while the thermit reaction provides a spectacular demonstration.

Common misunderstandings and misconceptions

The most complex ideas here relate to the different definitions of oxidation–reduction and their application to particular examples. It is important to maintain clarity in the presentation of the different examples. The use of the mnemonic 'oil rig' related to the definition in terms of electrons is very familiar, but remains very effective.

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Homework ideas

- Coursebook questions 4.9 and 4.10
- Worksheet 4.7 *Important redox reactions*

Topic 5 Electrolysis

Coursebook section 4.5 (pp. 102–112)

Teaching ideas

Introduce the conductivity of ionic compounds in the molten state, or in aqueous solution. Note that electrolysis results in the decomposition of the compound.

- The use of electrical energy to bring about chemical change is an important concept. The conditions in which electrolysis takes place, and the distinction between electrolysis and the electrical conductivity of metals, need to be clearly established.
- There is particular terminology linked to electrolysis and these words need to be clearly defined.
- Introduce the essential ideas using the more straightforward examples of the electrolysis of molten ionic compounds. A demonstration of the electrolysis of lead bromide can be useful in providing a memorable experimental focus, while the use of animations can be very helpful in supporting an explanation of the changes taking place at the electrodes.
- The choice of the examples selected for discussion, and the sequence in which they are worked through, are important to avoid confusion as students work through to the more complex examples in this topic.

Common misunderstandings and misconceptions

The main difficulty here is in the understanding of the processes of ion discharge at the electrodes. In this context, the use of animations is very helpful. It is also important to establish the basic ideas of these processes using the less complicated examples before progressing to the more complex examples. It is worth noting that the examples used on the Core papers will all be those where the products can be straightforwardly deduced from the name of the compound being electrolysed (even in solution).

Homework ideas

- End-of-chapter question 5 and Questions 4.11 to 4.14 in the Coursebook
- The movement of ions to electrodes is discussed in Exercise 4.6 *The movement of ions.*
- Exercise 4.3 *The nature of electrolysis* and Exercise 4.7 *Making and 'breaking' copper(II) chloride*
- Activity 4.2 *Web researching the extraction of aluminium* is an activity than can then be followed up by class discussion and presentations. Awareness of the economic and environmental implications of the very high energy demand for electrolysis is important here (and the link to the need for recycling of aluminium and the availability of hydroelectric power).

Topic 6 A closer look at electrode reactions

Coursebook section 4.6 (pp. 113–114)

Teaching ideas

Discuss the discharge of ions at the electrodes and key applications of electrolysis.

- The focus here is on the particular reactions that take place at the electrodes during electrolysis – certain important examples are highlighted in terms of oxidation and reduction, and of the distinctive products formed,
- The demonstration described on Worksheet 4.4 *A colourful electrolysis – demonstration* is a useful one to let students see the complexity of an example that has an industrial use. It is also one that can be followed up by a student practical (Activity 4.3 *The electrolysis of concentrated sodium chloride solution*).
- The application of electroplating is an important use of electrolysis and can be summarised in a series of simple rules.

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Common misunderstandings and misconceptions

Again, the main difficulty here is the understanding of the processes of ion discharge at the electrodes. In this context, the use of animations is very helpful.

Homework ideas

- Complete the questions on Worksheet 4.4 *A colourful electrolysis – demonstration* following the demonstration.
- Follow up Activity 4.4 *Electroplating copper with nickel* with a web search on the usefulness of electroplating.

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Teaching ideas

Chapter 5 Acids, bases and salts

Syllabus sections covered: 8.1; 8.2; 8.3

Teaching resources

Syllabus section	Topic	40-minute periods	Resources in Coursebook	Resources in Workbook	Resources on this CD-ROM
8.1	What is an acid?	1	Section 5.1 Questions 5.1 to 5.7		Worksheet 5.1 Acidity and alkalinity
8.1	Acid and alkali solutions	1	Section 5.2 Activity 5.2 Rainbow fizz! Questions 5.8 to 5.12 EOCQ 3 Internet animations, linked from CD-ROM: Acids, bases and salts; Reactions of acids		Worksheet 5.2 Reactions of acids and bases Worksheet 5.5 Acids and alkalis Worksheet 5.6 pH scale
8.2	Metal oxides and non-metal oxides	1	Section 5.3 Questions 5.13 to 5.19 EOCQ 5		
8.1	Acid reactions in everyday life	2	Section 5.4 Activity 5.1 Extracting an indicator from red cabbage Activity 5.3 Testing the pH of everyday substances Activity 5.4 Comparing the effectiveness of different antacid tablets Questions 5.20 to 5.22	Execise 5.3 Antacids Exercise 5.4 Fire extinguishers Exercise 5.5 Descaling a coffee machine	Worksheet 5.7 Antacid tablets
8.1	Alkalis and bases	1	Section 5.5 Questions 5.23 to 5.26		
8.1	Characteristic reactions of acids	3	Section 5.6 Activity 5.5 The reaction between an acid and an alkali Questions 5.27 to 5.29 EOCQ 4	Exercise 5.1 Acid–base reactions – neutralisation Exercise 5.7 Thermochemistry – investigating the neutralisation of an acid by an alkali	Worksheet 5.4 The reactions of acids

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Syllabus section	Topic	40-minute periods	Resources in Coursebook	Resources in Workbook	Resources on this CD-ROM
8.1; 8.4	Acids and alkalis in analysis	2	Section 5.7 Questions 5.30 to 5.32		
8.3	Salts	1	Section 5.8 Question 5.33 EOCQ 1	Execise 5.2 Types of salt	Worksheet 5.3 The significance of salt
8.3	Preparing soluble salts	3	Section 5.9 Activity 5.6 Quick and easy copper(II) sulfate crystals Questions 5.34 to 5.38 EOCQ 6, 7	Exercise 5.6 The analysis of titration results	
8.3	Preparing insoluble salts	1	Section 5.10 Activity 5.7 Making sparkling crystals of lead(II) iodide Question 5.39 Internet animations, linked from CD-ROM: Forming salts by precipitation	Exercise 5.8 Deducing a formula from a precipitation reaction	
8.1	Strong and weak acids and alkalis	2	Section 5.11 Questions 5.40 to 5.46 EOCQ 2 Activity 10.4 The acidic reactions of ethanoic acid		

Topic 1 What is an acid?

Coursebook section 5.1 (pp. 119–123)

Teaching ideas

This and the next topic form a general introduction to the ideas of what an acid is and the simple features of acids.

- The purpose of these introductory sessions is to introduce the ideas of acid–base behaviour and the notion of indicators and the pH scale, and to revisit ideas that students may have gained from earlier science courses.

Common misunderstandings and misconceptions

There are very few misconceptions or difficulties with this work.

Homework ideas

- Coursebook questions 5.1 to 5.7
- Worksheet 5.1 *Acidity and alkalinity*

Topic 2 Acid and alkali solutions

Coursebook section 5.2 (pp. 124–125)

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Teaching ideas

- Extend the ideas of acid–base behaviour and the notion of indicators and the pH scale. Explore the usefulness of single-change indicators such as methyl orange and litmus and the use of Universal Indicator in assessing the pH of a solution.

Common misunderstandings and misconceptions

The major point which may cause problems if not stressed is the nature of the pH scale and the fact that the scale works from the central, neutral value of 7. Thus, the more concentrated the acid solution, the lower the pH.

Homework ideas

- Use Worksheet 5.2 *Reactions of acids and bases* and Worksheet 5.5 *Acids and alkalis* to develop the concepts of an acid and a base (alkali).
- Coursebook questions 5.8 to 5.12 and End-of-chapter question 3
- Worksheet 5.6 *pH scale* is useful in developing the understanding of the pH scale and can be linked to Worksheet 1.10 *The acidification of the oceans*, which also discusses the nature of the scale.

Topic 3 Metal oxides and non-metal oxides

Coursebook section 5.3 (pp. 125–127)

Teaching ideas

Cover here the phenomenon of basic, amphoteric and acidic oxides.

- The phenomenon of acidic and basic oxides can be usefully demonstrated practically to the class by burning samples of a range of elements in gas jars of oxygen.
- The concept of amphoteric oxides and neutral oxides can also be covered here.
- The idea of amphoteric behaviour can later be linked to the analytical tests for certain metal ions.

Common misunderstandings and misconceptions

The central idea of acidic and basic oxides is relatively straightforward but that of amphoteric oxides can create misunderstanding and needs clear understanding and practical demonstration – the link to examples from the analytical tests can be helpful here.

Homework ideas

- Coursebook questions 5.13 to 5.19 and End-of-chapter question 5

Topic 4 Acid reactions in everyday life

Coursebook section 5.4 (pp. 127–129)

Teaching ideas

- The everyday occurrence and uses of acids and alkalis is also important in relating chemistry to the normal experience of students – a collection of supermarket products and over-the-counter medicines can be collected (Activity 5.3 *Testing the pH of everyday substances* and Activity 5.4 *Comparing the effectiveness of different antacid tablets*).
- Activity 5.3 also contains an additional note outlining a possible experiment on the neutralisation of an acid with slaked lime or powdered limestone – as an introduction to the use of lime in neutralising acid soil in agriculture/horticulture.
- Simple experiments can be carried out on fruit juices and some of the products above. If time permits, the extraction of an indicator from red cabbage or other plant source can be carried out as a class practical (Activity 5.1 *Extracting an indicator from red cabbage*). These indicators can be compared with single-change indicators such as methyl orange, phenolphthalein and litmus, and with Universal Indicator. The range of colours produced by the red cabbage indicator at different pHs can be assessed as a means of estimating the pH of a solution.

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Common misunderstandings and misconceptions

This is an area of the course where there are a good number of practical exercises to aid understanding.

Homework ideas

- Coursebook questions 5.20 to 5.22 can be used here.
- Exercise 5.3 *Antacids* and Worksheet 5.7 *Antacid tablets* cover the use of different hydroxides and carbonates for the relief of acid indigestion.
- Exercise 5.4 *Fire extinguishers* and Exercise 5.5 *Descaling a coffee machine* in the Workbook discuss practical applications of acid–base chemistry.

Topic 5 Alkalis and bases

Coursebook section 5.5 (pp. 129–131)

Teaching ideas

Define the difference between an alkali and a base.

- The content of this section introduces the nature of bases and the sub-division of such compounds often referred to as alkalis.
- The nature of alkalis as soluble bases can be developed and the role of sodium hydroxide solution in analysis introduced.

Common misunderstandings and misconceptions

The initial survey of the types of compound that are bases and the soluble sub-set known as alkalis is generally reasonably straightforward and can subsequently be reinforced by a range of practical work for the students.

Homework ideas

- Coursebook questions 5.23 to 5.26

Topic 6 Characteristic reactions of acids

Coursebook section 5.6 (pp. 131–134)

Teaching ideas

Discuss the characteristic reactions of acids with metals, bases and carbonates.

- The characteristic reactions of acids with metals, alkalis and carbonates can also be the subject of useful class practical(s) where students are encouraged to work safely and record observations carefully (see Activity 5.5 *The reaction between an acid and an alkali* and other simple practical experiments to produce hydrogen and carbon dioxide). Generating the word and balanced symbol equations for these reactions can also be a useful reinforcement of earlier work.
- Practical work on neutralisation reactions can include the introduction of titration and thermochemical approaches to determining the point of neutralisation.

Common misunderstandings and misconceptions

This is an area of the course where there are a good number of practical exercises to aid understanding.

Homework ideas

- End-of-chapter question 4 and Coursebook questions 5.27 to 5.29
- Exercise 5.1 *Acid–base reactions – neutralisation* and Exercise 5.7 *Thermochemistry – investigating the neutralisation of an acid by an alkali*
- Worksheet 5.4 *The reactions of acids*

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Topic 7 Acids and alkalis in analysis

Coursebook section 5.7 (pp. 134–135)

Teaching ideas

- The role of dilute hydrochloric acid in the test for a carbonate can be emphasised – and, given that it is now on the new syllabus, the parallel reaction of a sulfite with acid to give sulfur dioxide.
- The limewater test for carbon dioxide is also relevant here, both as a test for the gas in its own right, and as part of the carbonate test.
- The role of the alkalis sodium hydroxide solution and ammonia solution in analysis can be introduced.
- The test for ammonium salts involves the displacement of a weak alkali by a strong one, sodium hydroxide.

Common misunderstandings and misconceptions

These are practical tests and can be introduced as part of a strategy to develop an understanding of the analytic tests that are a key part of the practical content of the course.

Homework ideas

- Coursebook questions 5.30 to 5.32

Topic 8 Salts

Coursebook section 5.8 (pp. 136–138)

Teaching ideas

- Introduce the idea of salts as the derivatives of the different acids. Emphasise the key relationship between the major acids and the names (and formulae) of the salts produced from them.
- Give examples of the significant use of certain salts, particularly that of sodium chloride.

Common misunderstandings and misconceptions

There are few misconceptions that prevail in this basic introduction to this type of compound.

Homework ideas

- Coursebook question 5.33 and End-of-chapter question 1
- Exercise 5.2 *Types of salt* in the Workbook outlines the types of salt produced by different acids.
- The historical and practical importance of common salt is emphasised in Worksheet 5.3 *The significance of salt*.

Topic 9 Preparing soluble salts

Coursebook section 5.9 (pp. 138–141)

Teaching ideas

In these next topics, discuss the different approaches to salt preparation including titration and precipitation methods.

- This is a very practical section of the course, focusing on the different methods of preparing salts from the reaction between an acid and an appropriate reagent. The different methods can be approached systematically to emphasise the suitability of a particular method to a specific case.
- Students need to be clear on the choice of acid involved in making a particular salt – so nitric acid will always produce a nitrate, for instance.
- The procedural steps involved in the various methods, and their rationale, should be emphasised because these can be the subject of examination questions, as indeed can drawings of the apparatus for certain practical procedures.

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Common misunderstandings and misconceptions

There are few areas of misconception in this topic. Students need to aware of the procedures involved and be careful in their drawing of the apparatus for various techniques.

Homework ideas

- End-of-chapter questions 6 and 7 and Questions 5.34 to 5.38 in the Coursebook
- Students can practise the analysis of titration results using Exercise 5.6 *The analysis of titration results.*

Topic 10 Preparing insoluble salts

Coursebook section 5.10 (pp. 141–143)

Teaching ideas

- The preparation of an insoluble salt by precipitation needs to be demonstrated and the procedure carried out by the students.
- There is opportunity to discuss and revise the solubility rules for salts.
- The use of the quantity of precipitate formed in the calculation of the formula of a salt should be practised.

Common misunderstandings and misconceptions

The idea that some salts are insoluble and the preparation methods are straightforward but students can have difficulty with remembering which salts are insoluble and with the calculation method.

Homework ideas

- Exercise 5.8 *Deducing a formula from a precipitation reaction*
- Coursebook question 5.39

Topic 11 Strong and weak acids and alkalis

Coursebook section 5.11 (pp. 143–147)

Teaching ideas

- The work on acids and alkalis can be extended to discuss the nature of and distinction between strong and weak acids (and alkalis), introducing the idea of partial ionisation. The concept of partial ionisation of a covalent molecule will already have been raised in discussing the nature of water. These ideas can be linked to a discussion of reversible reactions.
- The practical consequences of an acid being weak are illustrated in Activity 10.4 *The acidic reactions of ethanoic acid* where this acid is compared with hydrochloric acid in a series of reactions.
- More sophisticated definitions of acids and bases can be elaborated.

Common misunderstandings and misconceptions

The conceptual difficulties arise when discussing the topic of weak and strong acids/alkalis. The practical demonstration of the differences between solutions of, say, hydrochloric acid and ethanoic acid are important in showing the reality of the distinction between a strong and a weak acid (Activity 10.4 *The acidic reactions of ethanoic acid*).

Homework ideas

- Coursebook questions 5.40 to 5.46 and End-of-chapter question 2

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Teaching ideas

Chapter 6 Quantitative chemistry

Syllabus sections covered: 4.1; 4.2

Teaching resources

Syllabus section	Topic	40-minute periods	Resources in Coursebook	Resources in Workbook	Resources on this CD-ROM
4.1	Chemical analysis and formulae	3	Section 6.1 Activity 6.1 Reacting marble chips with acid Questions 6.1 to 6.4 EOCQ 2	Exercise 6.1 Calculating formula masses Exercise 6.2 A sense of proportion in chemistry	Worksheet 6.1 Chemical proportions
4.2	The mole and chemical formulae	5	Section 6.2 Activity 6.2 Finding the composition of magnesium oxide Activity 6.5 Interpreting data on the solubility of solids and gases in water Questions 6.5 to 6.6 EOCQs 3, 5	Exercise 6.3 Calculating the percentage of certain elements in a compound and empirical formulae	Worksheet 6.2 The mole and chemical formulae Worksheet 6.5 Empirical formulae Worksheet 6.6 Dehydrating barium chloride crystals
4.2	The mole and chemical equations	5	Section 6.3 Activity 6.3 The effect of varying the quantity of a reactant Question 6.7 EOCQs 4, 6	Exercise 6.5 Finding the mass of 5 cm of magnesium ribbon Exercise 6.7 Calculation triangles Exercise 6.8 Scaling up!	Worksheet 6.3 Reacting masses
4.2	Calculations involving gases	2	Section 6.4 EOCQs 1, 7	Exercise 6.6 Reacting volumes of gases	Worksheet 6.4 Calculations involving gases and solutions
4.2	Moles and solution chemistry	4	Section 6.5 Activity 6.4 Determining the concentration of a hydrochloric acid solution Questions 6.8 to 6.10	Exercise 6.4 Calculations involving solutions	

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Topic 1 Chemical analysis and formulae

Coursebook section 6.1 (pp. 151–158)

Teaching ideas

- The scope of this material relates to the concepts of relative atomic mass and relative formula mass. The latter can be calculated from the former and students will be expected to do this, given either the formula or some diagrammatic representation of a molecule.
- This approach also allows the percentage composition of a compound to be worked out. These ideas can be practised using examples.
- Further calculations on reactions can be worked through in which the relationship between the mass of product from a given mass of reactant is defined – the student then has to use this proportionality for a different mass of reactant, say.

Common misunderstandings and misconceptions

There is no discussion of moles here and so the difficulties will relate to how confident a student is in handling arithmetical procedures and proportionality.

Homework ideas

- Exercise 6.1 *Calculating formula masses* and Exercise 6.2 *A sense of proportion in chemistry*
- *Worksheet 6.1 Chemical proportions*
- Coursebook questions 6.1 to 6.4 and End-of-chapter question 2

Topic 2 The mole and chemical formulae

Coursebook section 6.2 (pp. 158–161)

Teaching ideas

- Introduce the concept of the mole as a means of counting atoms/molecules. Pragmatically, it can be discussed in terms of being the 'formula mass in grams' of a substance, but some idea of the conceptual background gives students more rationale behind its use. The application to chemical formulae can be focused by using data from an experiment such as the one producing magnesium oxide from known masses of magnesium.
- The discussion of empirical formulae and molecular formulae follows from the above and begins to show the importance of the mole concept.

Common misunderstandings and misconceptions

This is a complex area and the analogy of counting coins in banks or ticket machines, for instance, is a useful one. The key then is to approach the examples systematically and establish a framework for tackling the types of question asked. Confidence is then built up and some of the mystery dispersed.

Homework ideas

- Worksheet 6.2 *The mole and chemical formulae*
- Exercise 6.3 *Calculating the percentage of certain elements in a compound and empirical formulae*
- Worksheet 6.5 *Empirical formulae* and Worksheet 6.6 *Dehydrating barium chloride crystals* give useful practice at particular types of problems.
- Coursebook questions 6.5 and 6.6 and End-of-chapter questions 3 and 5
- Activity 6.5 *Interpreting data on the solubility of solids and gases in water* gives useful practice at handling different types of data relating to concentration and the interpretation of graphs.

Topic 3 The mole and chemical equations

Coursebook section 6.3 (pp. 161–165)

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Teaching ideas

- Extend the ideas on the usefulness of the mole to include its relevance to chemical equations – the notion that an equation tells you not only what is produced in a reaction but also how much of each product. The equation defines the proportionality between reactant and product.
- Use examples to reinforce this idea – the thermal decomposition of calcium carbonate is a good place to start as the 'numbers' are favourable.
- Introduce the idea that such calculations make it possible to work out whether any reactant is in excess, and also calculate useful parameters (particularly industrially and in research) such as % yield.

Common misunderstandings and misconceptions

There are no particularly new areas of misconception here – students who have handled this topic so far can usually grasp the application to chemical reactions and their equations.

Homework ideas

- Worksheet 6.3 *Reacting masses*
- Complete the following exercises from the Workbook: Exercise 6.5 *Finding the mass of 5 cm of magnesium ribbon*, Exercise 6.7 *Calculation triangles* and Exercise 6.8 *Scaling up!*
- Coursebook question 6.7 and End-of-chapter questions 4 and 6

Topic 4 Calculations involving gases

Coursebook section 6.4 (pp. 165–166)

Teaching ideas

- The concept of the mole can be extended to gases – the molar volume of a gas is a useful and relatively simple concept as it has just one value. Remind students that they will be given this value at the foot of the Periodic Table they will receive in any exam.

Common misunderstandings and misconceptions

Students sometimes find the idea that the molar volume of a gas is the same for any gas difficult to grasp and they can make calculations more difficult than they are. Students can have difficulty with reacting proportions.

Homework ideas

- Worksheet 6.4 *Calculations involving gases and solutions*
- End-of-chapter questions 1 and 7 in the Coursebook
- Exercise 6.6 *Reacting volumes of gases*

Topic 5 Moles and solution chemistry

Coursebook section 6.5 (pp. 166–170)

Teaching ideas

- The concept of the mole can be extended to help define the concentrations of solutions and therefore the proportions in which they will react with each other. This is important in the context of titrations and offers opportunity for extensive practical work to help reinforce the applicability of the mole concept.
- Support the development of these ideas with practical work and develop strategies for working through the calculations in a stepwise manner.

Common misunderstandings and misconceptions

The calculations relating to titrations can be difficult and therefore should be approached in a systematic way. It is useful to note that, in an examination, any question on moles is often broken down systematically into useful, structured stages. This can be reassuring to students but they should be able to carry through a whole calculation unprompted.

Homework ideas

- Coursebook questions 6.8 to 6.10
- Exercise 6.4 *Calculations involving solutions*

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Teaching ideas

Chapter 7 How far? How fast?

Syllabus sections covered: 6; 7.1; 7.3

Teaching resources

Syllabus section	Topic	40-minute periods	Resources in Coursebook	Resources in Workbook	Resources on this CD-ROM
6.1; 6.2	Energy changes in chemical reactions	4	Section 7.1 Activity 7.1 Exothermic and endothermic reactions Activity 7.2 Comparing the energy from different fuels Activity 7.3 Energy changes in metal displacement reactions Questions 7.1 to 7.5	Exercise 7.1 Terms of reaction Exercise 7.2 Energy diagrams	Worksheet 7.1 Thermochemistry Worksheet 7.4 Bond energies Worksheet 7.5 Energy changes during combustion Worksheet 7.6 Heats of reaction
7.1	Rates of reaction	5	Section 7.2 Activity 7.4 The factors affecting reaction rate Activity 7.5 The effect of concentration on rate of reaction Questions 7.6 to 7.9 EOCQs 1, 3, 4, 5 Internet animations, linked from CD-ROM: Rates of reaction	Exercise 7.3 The collision theory of reaction rates Exercise 7.4 The influence of surface area on the rate of reaction Exercise 7.5 Finding the rate of reaction producing a gas Exercise 7.6 Runaway reactions Exercise 7.7 CCS (carbon capture and storage)	Worksheet 7.2 Rates of reaction Worksheet 7.7 Acid and thiosulfate reaction
7.1	Catalysts	2	Section 7.3 Questions 7.10 to 7.16		Worksheet 11.6 Enzymes in industry
7.1	Photochemical reactions	1	Section 7.4 Questions 7.17 to 7.21		Worksheet 12.5 Silver halides

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Syllabus section	Topic	40-minute periods	Resources in Coursebook	Resources in Workbook	Resources on this CD-ROM
7.3	Reversible reactions and chemical equilibria	4	Section 7.5 Activity 7.6 A reversible reaction involving copper(II) sulfate Questions 7.22 to 7.27 EOCQs 2, 6 Internet animations, linked from CD-ROM: Reversible reactions and dynamic equilibrium	Exercise 7.8 Reversible reactions involving inter-halogen compounds	Worksheet 7.3 Reversible reactions Worksheet 7.8 Heating copper(II) sulfate crystals

Topic 1 Energy changes in chemical reactions

Coursebook section 7.1 (pp. 174–181)

Teaching ideas

Discuss the basis of exothermic and endothermic reactions linked to bond breaking and making.

- The focus of this topic is the explanation of exothermic and endothermic reactions in terms of bond breaking and subsequent bond making. This relates back to the idea of reactions being a recombination of the atoms present in the reactants. An excellent animation to help visualise this idea is found at: http://www.inquiryinaction.org/chemistryreview/chemical_change/
- This animation deals with the example of methane burning in oxygen, just like the example given in the Coursebook. Students should be taken carefully through the calculation to avoid confused addition and subtraction.
- The practical aspects of thermochemistry can also be discussed using the exercise in the Workbook met earlier (Exercies 5.7 *Thermochemistry – investigating the neutralisation of an acid by an alkali*). Using 'light sticks' to show that energy can also be released from certain reactions in the form of light can be a telling demonstration for students.
- Students need to be able to construct energy diagrams for both exothermic and endothermic reactions. Practise these for the reactions considered in both theory and experiments. Students should be able to construct these diagrams in general terms and when given the data for a particular reaction.
- Use bond energy data to calculate the heat of reaction for a chemical change. This will entail a clear picture of the bonding in the reactants and products.

Common misunderstandings and misconceptions

There are relatively few misconceptions here although, as mentioned, students should be taken carefully through the calculations involved to avoid confused addition and subtraction.

Homework ideas

- Worksheet 7.1 *Thermochemistry* and Exercise 7.1 *Terms of reaction*
- Coursebook questions 7.1 to 7.5
- Worksheet 7.5 *Energy changes during combustion* deals with combustion data.
- Exercise 7.2 *Energy diagrams*, Worksheet 7.4 *Bond energies* and Worksheet 7.6 *Heats of reaction* give practice at the construction of energy level diagrams and the calculation of heat of reaction.

Topic 2 Reaction rates

Coursebook section 7.2 (pp. 181–187)

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Teaching ideas

Introduce the ideas of reaction rate and the practical methods of following particular reactions. Discuss the factors that influence reaction rates. Introduce the collision theory.

- Discuss the concept of rate (or speed) of reaction in terms of the using up of a reactant, or the increase in amount of a product, with time. This topic has a very good range of practical possibilities and a key 'decision' is which method to use to 'follow' a reaction in a particular case. This means that experiments in this area are good examples to discuss with students in terms of planning – particularly as students will need to be careful to make the conditions comparable if they are to study the effect of, say, temperature on a reaction rate.
- The idea that a reaction will be fastest at the start and then slow as reactants are used up is important for students to grasp, as is the notion that one or other reactant may restrict the amount of product formed – the reactant that is not in excess.
- There are several examples of reactions that are frequently studied and it is useful if students see all of these – either demonstrated or carried out as practical activities for themselves. These reactions also lend themselves well to data logging. It can add a new dimension to understanding if students see the curves produced appearing on screen as the experiment proceeds.

Common misunderstandings and misconceptions

The key factor here seems to be ensuring that students realise that the rate of reaction is a measure against time – a measure of how far a reaction has gone in a given amount of time. Stress that this can be measured by following the disappearance of a reactant or the appearance of a product of the reaction. Otherwise, there are relatively few misconceptions here and the main focus is on clearly defining which method is most appropriate to a given reaction and how to control the parameters of a particular experiment.

Homework ideas

- Worksheet 7.2 *Rates of reaction* and Worksheet 7.7 *Acid and thiosulfate reaction*
- Exercise 7.3 *The collision theory of reaction rates* and Exercise 7.4 *The influence of surface area on the rate of reaction*
- Exercise 7.5 *Finding the rate of a reaction producing a gas*
- Exercise 7.6 *Runaway reactions* and *Exercise 7.7 CCS (carbon capture and storage)* in the Workbook provide novel approaches to the treatment of reaction rates to encourage students to apply their knowledge to unusual examples.
- Coursebook questions 7.6 to7.9 and End-of-chapter questions 1, 3, 4 and 5

Topic 3 Catalysts

Coursebook section 7.3 (pp. 187–193)

Teaching ideas

Extend discussion of collision theory to include the role of catalysts.

- The idea of a catalyst should be introduced here and again there are certain experiments that demonstrate this well – the decomposition of hydrogen peroxide catalysed by manganese(IV) oxide being the one most used.
- Link to the key industrial processes – the Haber process and the Contact process – and also to the role of transition metals and their compounds as catalysts (including the catalytic converter in cars). One interesting approach is where students compare the effect of adding different transition metal oxides to a mixture of hydrogen peroxide and kitchen detergent. The oxides catalyse the decomposition of the hydrogen peroxide into water and oxygen. The water and oxygen cause the detergent to become a foam column. The experiment is carried out in a 100 cm^3 measuring cylinder, and students measure the height of the foam column produced in a fixed time period.
- Include discussion of enzymes as biological catalysts. The above experiment on the catalytic decomposition of hydrogen peroxide can be adapted to use an enzyme found in nearly all living organisms. This enzyme,

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catalase, is the fastest known enzyme. Students grind up small amounts of potato, liver and celery, and then place these into separate measuring cylinders. 2 cm^3 of detergent is added to each. Students then pour on 15 cm^3 of hydrogen peroxide. The resulting oxygen production causes foam to be produced. Students can attempt to relight a glowing splint by touching it on to the foam.

Common misunderstandings and misconceptions

The key point here is care with the definition of a catalyst – it must not include any suggestion that the catalyst 'does not take part' in the reaction.

Homework ideas

- Use Coursebook questions 7.10 to 7.17 in this context.
- Carry out a web search on a selected enzyme (catalase or pepsin, for example) – focus on issues such as specificity, sensitivity to pH and temperature.
- Link the last suggestion to Worksheet 11.6 *Enzymes in industry*.

Topic 4 Photochemical reactions

Coursebook section 7.4 (pp. 193–194)

Teaching ideas

- Discussion of photochemical reactions should also be carried out here – including a revision of photosynthesis.
- Students could produce simple negative images of, say, a key using filter paper soaked in silver chloride and exposed to light.

Common misunderstandings and misconceptions

There are no major area of misconception on this topic.

Homework ideas

- Coursebook questions 7.17 to 7.21 are useful here.
- Worksheet 12.5 *Silver halides*

Topic 5 Reversible reactions and chemical equilibria

Coursebook section 7.5 (pp. 194–200)

Teaching ideas

Introduce simple reactions that can be reversed. Move on to discuss reversible reactions in which an equilibrium is set up. Introduce key industrial processes and the effect of changing conditions on the yield of product.

- The initial reactions considered here are those that can be reversed by 're-mixing' – the dehydration of copper(II) sulfate or the thermal decomposition of ammonium chloride, for instance. Discuss and carry out class practical activities of these reactions (Activity 7.6 *A reversible reaction involving copper(II) sulfate* and Activity 12.1 *Analysing the make-up of a compound*). Point out that heating hydrated cobalt(II) chloride crystals will produce a similar effect to the copper(II) sulfate experiment.
- Following the discussion of the simple experiments described above, it is necessary to move on to the more complex examples where equilibrium is set up between the forward and reverse reactions of a reversible reaction. The idea of a dynamic equilibrium is best supported by the use of suitable analogies and then discussed in terms of particular examples.
- There are certain very important industrial examples that can be referred to here – and they have the advantage that they will be revisited later. The example of the inter-halogen compounds referred to in Exercise 7.8 *Reversible reactions involving inter-halogen compounds* in the Workbook can be set up as a demonstration. For details see: http://www.practicalchemistry.org/experiments/intermediate/reversible-reactions/le-chateliers-principle-theeffect-of-concentration-and-temperature-on-an-equilibrium,182,EX.html

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- A simpler, colourful demonstration of an equilibrium that can be switched back and forth by the addition of acid or alkali is that involving dichromate/chromate ions. http://www.practicalchemistry.org/experiments/intermediate/reversible-reactions/an-equilibrium-involvingchromatevi-and-dichromatevi-ions,284,EX.html
- The effect of changing conditions on the position of equilibrium should be discussed in terms of these examples and a clear summary that can be applied generally given to the students.

Common misunderstandings and misconceptions

This develops into a conceptually difficult area so the use of appropriate analogies is important. It is also useful to use the examples quoted to generate some simple rules that students can apply to the reactions they will be presented with in the examination.

Homework ideas

- Worksheet 7.3 *Reversible reactions* and Worksheet 7.8 *Heating copper(II) sulfate crystals*
- Exercise 7.8 *Reversible reactions involving inter-halogen compounds*
- Coursebook questions 7.22 to 7.27 and End-of-chapter questions 2 and 6

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Teaching ideas

Chapter 8 Patterns and properties of metals

Syllabus sections covered: 5; 9.3; 9.4; 10.2; 10.3

Teaching resources

Syllabus section	Topic	40-minute periods	Resources in Coursebook	Resources in Workbook	Resources on this CD-ROM
9.3	The alkali metals	3	Section 8.1 Questions 8.1 to 8.7	Exercise 8.1 Group I: The alkali metals	Worksheet 8.1 The alkali metals
5; 10.2; 10.3	Aluminium	1	Section 8.2 Questions 8.8 to 8.11	Exercise 8.5 Metals and alloys	
9.4	The transition elements	2	Section 8.3 Questions 8.12 to 8.16 EOCQ 1		Worksheet 8.7 Rusting
10.2; 10.3	The reactivity of metals	3	Section 8.4 Activity 8.1 Extracting metals with charcoal Activity 8.2 Reacting iron wool with steam Activity 8.3 Displacement reactions of metals Activity 8.4 The reactivity series Questions 8.17 to 8.21 EOCQs 2, 3 Animations on CD-ROM: The reactivity series Internet animations, linked from CD-ROM: Displacement reactions	Exercise 8.2 The reactivity series of metals Exercise 8.3 Energy from displacement reactions	Worksheet 8.2 Metals and reactivity Worksheet 8.5 Metals from their ores Worksheet 8.6 Reactions of powdered metals with metal oxides
5	Electrical cells and energy	3	Section 8.5 Activity 8.5 Investigating electrochemical cells Questions 8.22 to 8.23 EOCQ 4 Internet animations, linked from CD-ROM: Electrochemical cells	Exercise 8.4 Electrochemical cells	Worksheet 8.3 Reactivity and electrochemical cells Worksheet 8.4 Energy from metals

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Topic 1 The alkali metals

Coursebook section 8.1 (pp. 206–210)

Teaching ideas

The lesson should reinforce the ideas met earlier in terms of the reactivity of the alkali metals. If the demonstration of the reaction with water was not carried out earlier, then it should be now.

- The focus should now be also on discussing the trends in both physical and chemical properties in the group – and also how they compare with other metals elsewhere in the Periodic Table.
- Students should be able to predict/estimate trends in properties and values of physical parameters within the group.

Common misunderstandings and misconceptions

This topic gives rise to relatively few misconceptions. The key is to give students guidelines as to how to predict and discuss trends in properties – often the language to use is the difficulty. Help with how to estimate values of physical parameters is useful.

Homework ideas

- Worksheet 8.1 *The alkali metals*
- Exercise 8.1 *Group I: The alkali metals*
- Coursebook questions 8.1 to 8.7

Topic 2 Aluminium

Coursebook section 8.2 (pp. 210–212)

Teaching ideas

The aim here is to introduce the general properties and usefulness of aluminium – discussing how its relatively low density, resistance to corrosion and strength make it a very useful material for a variety of uses.

Common misunderstandings and misconceptions

There are no particular sources of misconception or difficulty here.

Homework ideas

- Coursebook questions 8.8 to 8.11
- Exercise 8.5 *Metals and alloys*

Topic 3 The transition elements

Coursebook section 8.3 (pp. 212–215)

Teaching ideas

The aim here is to introduce the general and distinctive properties of transition metals and compare them to metals from other regions of the Periodic Table. Physical properties such as density and strength, the colour of their compounds and their multiple oxidation states can be discussed – with reference to examples of examination questions to illustrate the major points.

- A comparison can be made between iron and aluminium in terms of resistance to corrosion.

Common misunderstandings and misconceptions

There are no particular sources of misconception or difficulty here.

Homework ideas

- Worksheet 8.7 *Rusting*
- Coursebook questions 8.12 to 8.16 and End-of-chapter question 1

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Topic 4 The reactivity of metals

Coursebook section 8.4 (pp. 215–220)

Teaching ideas

- This topic draws on reactions that have been met before and focuses on the displacement reactions of metals to draw up the reactivity series. A range of practical activities can be carried out by the students to establish the series – some of these experiments are good exercises for training in planning and evaluation.
- The demonstration of the thermit reaction could be carried out here if it was not done earlier. Discuss other reactions between powdered metals and metal oxides as examples of redox/displacement reactions.

Common misunderstandings and misconceptions

There are no particular sources of misconception or difficulty here provided clear guidelines are provided as a basis for interpreting the experiments.

Homework ideas

- Coursebook questions 8.17 to 8.21 and End-of-chapter questions 2 and 3
- Exercise 8.2 *The reactivity series of metals* and Exercise 8.3 *Energy from displacement reactions*
- Worksheet 8.2 *Metals and reactivity* and Worksheet 8.5 *Metals from their ores*
- Worksheet 8.6 *Reactions of powdered metals with metal oxides* covers the analysis of experimental results and is a useful substitute for carrying out some experiments which would be quite dangerous in the lab.

Topic 5 Electochemical cells and energy

Coursebook section 8.5 (pp. 221–222)

Teaching ideas

- The evaluation of the different reactivities of metals can also be explored by setting up electrochemical cells and noting the voltages achieved by different combinations of metals. Students should be made aware of simple rules that can be applied to help them make predictions in this area. The method of making a simple battery given on the web can provide a novel class activity or demonstration: http://www.chemicalconnection.org.uk/chemistry/experiments/list.php

Common misunderstandings and misconceptions

There are no particular sources of misconception here but clear guidelines need to be given regarding the direction of electron flow and the charge and naming of the electrodes. (The rule outlined in Worksheet 4.6 *Chemical mnemonics* is important here.)

Homework ideas

- Coursebook questions 8.22 to 8.23 and End-of-chapter question 4
- Worksheet 8.3 *Reactivity and electrochemical cells* and Worksheet 8.4 *Energy from metals*
- Exercise 8.4 *Electrochemical cells*

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Teaching ideas

Chapter 9 Industrial inorganic chemistry

Syllabus sections covered: 5; 10.3; 11.2; 11.3; 12; 13

Teaching resources

Syllabus section	Topic	40-minute periods	Resources in Coursebook	Resources in Workbook	Resources on this CD-ROM
10.3; 11.2	The extraction of metals by carbon reduction	4	Section 9.1 Activity 9.1 Preventing rusting Activity 9.2 Investigating how air is involved in rusting Activity 9.3 The extraction of copper and the reactivity series Questions 9.1 to 9.8 EOCQs 3, 4, 5, 6 Activity 8.1 Extracting metals with charcoal Internet animations, linked from CD-ROM: An overview of industrial chemistry; Iron and steel making; The thermit reaction	Exercise 9.1 Metal alloys and their uses	Worksheet 9.1 The blast furnace
5; 10.3	The extraction of metals by electrolysis	2	Section 9.2 Questions 9.9 to 9.13 EOCQ 7	Exercise 9.2 Extracting aluminium by electrolysis	Worksheet 9.2 The extraction of aluminium
11.3	Ammonia and fertilisers	3	Section 9.3 Activity 9.4 Making a fertiliser Questions 9.14 to 9.18 Internet animations, linked from CD-ROM: The Haber process	Exercise 9.3 The importance of nitrogen	Worksheet 9.3 The Haber process Worksheet 9.5 NPK fertilisers
12	Sulfur and sulfuric acid	2	Section 9.4 Questions 9.19 to 9.22	Exercise 9.4 Making sulfuric acid industrially	

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Syllabus section	Topic	40-minute periods	Resources in Coursebook	Resources in Workbook	Resources on this CD-ROM
5; 11.1	The chlor–alkali industry	2	Section 9.5 Questions 9.23 to 9.26	Exercise 9.6 The chlor–alkali industry	Worksheet 9.4 The industrial electrolysis of brine
13	Limestone	1	Section 9.6 Questions 9.27 to 9.31 EOCQ 2 Animation on CD-ROM: Making concrete	Exercise 9.5 Concrete chemistry	
Introduction	The economics of the chemical industry	1	Section 9.7 Questions 9.32 to 9.34 EOCQ 1	Exercise 9.7 Making sodium carbonate	

Topic 1 The extraction of metals by carbon reduction

Coursebook section 9.1 (pp. 226–233)

Teaching ideas

- Outline the extraction of iron in the blast furnace, including details of the raw materials fed into the furnace, details of the reactions taking place and the removal of impurities. Discuss the making of steel from iron, and the composition of various forms of steel and their purpose.
- Discuss and summarise rusting and the various methods of preventing it. Contrast this again with the resistance to corrosion of certain other metals, particularly aluminium.
- Extend the ideas involved in the blast furnace method for iron to the extraction of zinc.
- The 'Alchemy' resource from the Royal Society of Chemistry (UK) gives details and resources for a series of industrially important processes, including the blast furnace, the extraction of aluminium and the refining of copper: http://www.rsc.org/Education/Teachers/Resources/Alchemy/

Common misunderstandings and misconceptions

There are no substantial misconceptions associated with this topic.

Homework ideas

- Worksheet 9.1 *The blast furnace*
- Coursebook questions 9.1 to 9.8 and End-of-chapter questions 3, 4, 5 and 6
- Exercise 9.1 *Metal alloys and their uses*

Topic 2 The extraction of metals by electrolysis

Coursebook section 9.2 (pp. 234–235)

Teaching ideas

- Identify the main ore of aluminium as bauxite. Note that the purification to alumina is not required.
- Discuss the detail of the electrolysis of molten aluminium oxide to obtain aluminium. Comment on the use of cryolite, the structure of the electrolytic cell and the burning up of the graphite anodes with time. Give the electrode half-equations.

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Common misunderstandings and misconceptions

There are no particular sources of misconception or difficulty here.

Homework ideas

- Exercise 9.2 *Extracting aluminium by electrolysis*
- Worksheet 9.2 *The extraction of aluminium*
- Coursebook questions 9.9 to 9.13 and End-of-chapter question 7

Topic 3 Ammonia and fertilisers

Coursebook section 9.3 (pp. 235–238)

Teaching ideas

- Outline the Haber process giving details of the sources of nitrogen and hydrogen and the conditions used for the process. Discuss the nature of the equilibrium established and the effect of changing conditions on the position of that equilibrium. Outline the theoretical and economic reasons for the conditions chosen. There are computer simulations available for this process that can be helpful. For example: http://www.newbyte.com/uk/software/chemistry/
- Describe the main reactions and conditions involved in the Contact process for making sulfuric acid and discuss the conditions chosen for the central stage of this process, which is again an example of a dynamic equilibrium.
- Outline the importance of ammonia and sulfuric acid in the making of fertilisers. Discuss the role of NPK fertilisers. Outline the other uses of these two important industrial chemicals, and of sulfur dioxide.

Common misunderstandings and misconceptions

The discussion of these processes gives opportunity to revisit reversible reactions and the effects of changing conditions on the equilibrium position and the yield of product.

Homework ideas

- Exercise 9.3 *The importance of nitrogen industrially*
- Coursebook questions 9.14 to 9.18
- Worksheet 9.3 *The Haber process* and Worksheet 9.5 *NPK fertilisers*

Topic 4 Sulfur and sulfuric acid

Coursebook section 9.4 (pp. 238–241)

Teaching ideas

Describe the making of sulfuric acid by the Contact process. Include the uses of the acid and of sulfur dioxide.

- Discuss the conversion of sulfur dioxide to sulfur trioxide as a reversible reaction and the effect of varying the conditions on the yield of product – including the role of the catalyst.
- Comment on the reactions of dilute sulfuric acid as revision of content met earlier. Also develop the different activities of the concentrated acid as a dehydrating agent and oxidising agent.
- Describe sulfur dioxide as an acidic gas used as a bleach and disinfectant. Comment on its role in acid rain.

Common misunderstandings and misconceptions

There are a number of revision links here to material met previously. Stress the Contact process as an economically significant example of a reversible reaction. Students can find the effect of conditions on the position of an equilibrium difficult, so use this example to help with clarifying this topic.

Homework ideas

- Exercise 9.4 *Making sulfuric acid industrially*
- Coursebook questions 9.19 to 9.22

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Topic 5 The chlor-alkali industry

Coursebook section 9.5 (pp. 241–242)

Teaching ideas

The electrolysis of sodium chloride has previously been carried out as a demonstration and/or class experiment. Here the ideas involved are developed to show how this application of electrolysis is carried out industrially. Outline the electrode reactions, the essential features of the cell and the usefulness of the products obtained.

Common misunderstandings and misconceptions

There are no major misconceptions associated with this application of electrolysis.

Homework ideas

- Worksheet 9.4 *The industrial electrolysis of brine*
- Exercise 9.6 *The chlor–alkali industry*
- Coursebook questions 9.23 to 9.26

Topic 6 Limestone

Coursebook section 9.6 (pp. 242–245)

Teaching ideas

Discuss the conversion of limestone to lime and the uses of both the starting material and the product.

- The re-landscaping of exhausted quarries can be a lead-in to discussions on land reclamation and the issues surrounding the siting of industrial plants. This is generalised discussion and useful as such, though it is not a syllabus requirement.

Common misunderstandings and misconceptions

There are no major misconceptions associated with this topic.

Homework ideas

- Exercise 9.5 *Concrete chemistry*
- Coursebook questions 9.27 to 9.31

Topic 7 The economics of the chemical industry

Coursebook section 9.7 (pp. 245–247)

Teaching ideas

- The recycling of metals such as iron/steel and aluminium should be discussed. Discuss the importance of recycling as a means of conserving resources. The example of aluminium recycling is a clear case that illustrates the advantages.
- Link to issues raised in Chapter **1** regarding renewable and non-renewable resources and the search for alternative energy resources. Include here a reference to biogas – this has been the subject of exam questions.
- Outline the economics involved in the siting of an industrial plant and the environmental/pollution issues that need to be considered.

Common misunderstandings and misconceptions

There are no major misconceptions associated with this topic.

Homework ideas

- Coursebook questions 9.32 to 9.34
- Exercise 9.7 *Making sodium carbonate*

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Teaching ideas

Chapter 10 Organic chemistry

Syllabus sections covered: 14

Teaching resources

Syllabus section	Topic	40-minute periods	Resources in Coursebook	Resources in Workbook	Resources on this CD-ROM
Introduction 14.1	The unique properties of carbon	1	Section 10.1 Questions 10.1 to 10.4 EOCQs 1, 2	Exercise 10.1 Families of hydrocarbons	Worksheet 10.6 The versatility of carbon
14.1; 14.4	Alkanes	2	Section 10.2 Activity 10.1 Testing alkanes and alkenes Questions 10.5 to 10.11 Internet animations, linked from CD-ROM: Alkanes		Worksheet 10.1 Alkanes Worksheet 10.5 Burning hydrocarbons
14.1; 14.5	Alkenes	2	Section 10.3 Questions 10.12 to 10.17	Exercise 10.2 Unsaturated hydrocarbons (the alkenes)	
14.3	Hydrocarbon structure and isomerism	3	Section 10.4 Activity 10.2 Modelling the structures of hydrocarbon isomers Questions 10.18 to 10.24 EOCQ 3		Worksheet 10.2 Alkenes and isomerism
14.1; 14.4	Chemical reactions of the alkanes	1	Section 10.5 Questions 10.25 to 10.32 EOCQ 4	Exercise 10.5 Hydrocarbons and their reactions	
14.1; 14.5	Chemical reactions of the alkenes	3	Section 10.6 Questions 10.33 to 10.37		
14.6	Alcohols	2	Section 10.7 Activity 10.3 The fermentation of glucose using yeast Questions 10.38 to 10.43		Worksheet 10.3 Alcohols

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Syllabus section	Topic	40-minute periods	Resources in Coursebook	Resources in Workbook	Resources on this CD-ROM
14.6; 14.7	The reactions of ethanol	2	Section 10.8 Questions 10.44 to 10.48	Exercise 10.3 The alcohols as fuels Exercise 10.6 The chemistry of butanol	
14.7	Organic acids and esters	3	Section 10.9 Activity 10.4 The acidic reactions of ethanoic acid Activity 10.5 Making esters from alcohols and acids Questions 10.49 to 10.51 EOCQ 5 Internet animations, linked from CD-ROM: Esters	Exercise 10.4 Reactions of ethanoic acid	Worksheet 10.4 Organic acids and esters

Topic 1 The unique properties of carbon

Coursebook section 10.1 (pp. 252–254)

Teaching ideas

- Introduce the versatility of carbon by referring to the allotropes of carbon itself, and the ability of carbon to form chains, rings and multiple bonds.
- Point out the significance of carbon as the basis of life.

Common misunderstandings and misconceptions

This is introductory material and initially should be pitched at a level that is comprehensible to all students.

Homework ideas

- Coursebook questions 10.1 to 10.4 and End-of-chapter questions 1 and 2
- Exercise 10.1 *Families of hydrocarbons*
- Worksheet 10.6 *The versatility of carbon*

Topic 2 Alkanes

Coursebook section 10.2 (pp. 254–257)

Teaching ideas

- Outline the properties of carbon that give rise to the incredible versatility of this element in forming compounds. Introduce the alkanes as the first of many series of compounds based on extended chain length and branching. Discuss the gradual change in various physical properties of the alkanes.
- Discuss the 'saturated' nature of these molecules and their limited reactivity. Discuss their combustion in a plentiful and a limited supply of air/oxygen.
- Use molecular models (and computer graphics) to show how chains are built.

Common misunderstandings and misconceptions

There would appear to be few possibilities of misconception here given that organic chemistry is well structured and systematic. However, as the subject develops, some students lose the sense of identity of a particular series of compounds and all compounds begin to look the same. The differences between the 'families' need to be clear and repeatedly emphasised, while the use of molecular models is important in understanding and visualising the structures involved.

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Homework ideas

- Worksheet 10.1 *Alkanes*
- Coursebook questions 10.5 to 10.11

Topic 3 Alkenes

Coursebook section 10.3 (pp. 257–259)

Teaching ideas

- Discuss the additional group of hydrocarbons made possible by the fact that carbon atoms can form double bonds with each other.
- Introduce and stress the idea of a homologous series and use molecular models to demonstrate the structures involved. Outline the difference between the molecular formula and structural formula of a compound.
- Discuss the gradation of physical properties in the alkanes and alkenes with increasing chain length.
- Introduce the idea of a functional group as the part of the molecule that generates the characteristic reactions of a series. Also introduce the notion of a general formula for a series.

Common misunderstandings and misconceptions

There are no particular sources of misconception at this stage in the discussion provided the presentation is systematic.

Homework ideas

- Exercise 10.2 *Unsaturated hydrocarbons (the alkenes)*
- Coursebook questions 10.12 to 10.17

Topic 4 Hydrocarbon structure and isomerism

Coursebook section 10.4 (pp. 259–261)

Teaching ideas

Introduce the idea of isomerism and use examples of alkanes and alkenes to demonstrate the phenomenon.

Common misunderstandings and misconceptions

The phenomenon of isomerism can be a source of difficulty. This can be countered by the use of opportunities to solve problems using molecular models (see Activity 10.2 *Modelling the structures of hydrocarbon isomers*).

Homework ideas

- Worksheet 10.2 *Alkenes and isomerism*
- Coursebook questions 10.18 to 10.24 and End-of-chapter question 3

Topic 5 Chemical reactions of the alkanes

Coursebook section 10.5 (pp. 262–263)

Teaching ideas

- Outline the relative unreactivity of the alkanes.
- Discuss the combustion of the alkanes – complete and incomplete – and the economic importance of these reactions. There are two impressive demonstrations that involve the combustion of methane gas. Both need to be practised in advance of the lesson, but both of these are worthwhile and memorable.
  - **Methane bomb!** This first demonstration needs a clean and empty paint can that has a 0.5 cm hole in the lid, and a 1 cm hole near the bottom of the curved vertical side. Make sure that the lid is on tightly and fill the can with methane gas. Ensure that all the air is forced out as you fill the can. Light the gas at the top hole (on the lid) and stand back. It will burn with a yellow flame that will gradually get smaller and bluer as oxygen is drawn into the can. When the flame disappears inside the can, an explosive mixture of methane/oxygen is reached and the lid will blow off with a bang!

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- **Methane mamba!** This is another excellent demonstration but again it must be practised in advance. A simple version of this may be carried out by adding soapy water to a glass trough and bubbling methane gas through it. A small amount of the bubbles can be scooped off and ignited in your hands a safe distance from the gas source.
- Outline the substitution reactions of the alkanes with chlorine – an example of photochemical reactions.

Common misunderstandings and misconceptions

Stress the commonality of the products of the combustion reactions of the alkanes, and indeed of all the hydrocarbons. Work on the equations for these reactions as some can be difficult to balance for students.

Homework ideas

- Coursebook questions 10.25 to 10.32 and End-of-chapter question 4
- Exercise10.5 *Hydrocarbons and their reactions*

Topic 6 Chemical reactions of the alkenes

Coursebook section 10.6 (pp. 263–264)

Teaching ideas

- Outline the reactivity of the alkenes and the addition reactions they take part in. Describe and demonstrate the test for alkenes using bromine water.
- Comment on the ideas of saturation and unsaturation in the context of these series of hydrocarbons.

Common misunderstandings and misconceptions

There are few difficulties here but the distinction between the substitution reactions of the alkanes and the addition reactions of the alkenes should be clearly outlined.

Homework ideas

- Coursebook questions 10.33 to 10.37

Topic 7 Alcohols

Coursebook section 10.7 (pp. 265–267)

Teaching ideas

- Introduce the alcohols as a homologous series having the functional group (–OH) attached to a hydrocarbon chain. Examine the structure of the first few alcohol molecules and discuss the isomerism of propanol.
- Outline the industrial preparation of ethanol and compare the advantages and disadvantages of the two main methods. Demonstrate fermentation (Activity 10.3 *The fermentation of glucose using yeast*) and the purification of ethanol by fractional distillation (see Activity 2.3 *Distillation of mixtures*).

Common misunderstandings and misconceptions

There are few misconceptions with this topic.

Homework ideas

- Worksheet 10.3 *Alcohols*
- Coursebook questions 10.38 to 10.43

Topic 8 The reactions of ethanol

Coursebook section 10.8 (pp. 267–269)

Teaching ideas

- Discuss the uses of ethanol as a fuel.
- Outline the reactions of ethanol – particularly oxidation and esterification.

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Common misunderstandings and misconceptions

Students can have difficulties with some of the structures involved here so clarity of presentation and the use of models, etc., is important.

Homework ideas

- Exercise 10.3 *The alcohols as fuels*
- Coursebook questions 10.44 to 10.48
- Work through Exercise 10.6 *The chemistry of butanol* in the Workbook, which includes reference to using the alcohols as fuels and to isomerism.

Topic 9 Organic acids and esters

Coursebook section 10.9 (pp. 269–271)

Teaching ideas

Introduce the carboxylic acids as the product of oxidation of alcohols. Discuss the oxidation of wine to vinegar. Outline the structure of the carboxylic acid group, and hence the structure of the early acids in the series – again, molecular models can be useful for visualising these structures. The 'Molecule of the month' site from Bristol University in the UK has computer graphics of many structures (and notes) ranging from methane and ethene to linoleic acid (used for making margarine): http://www.chm.bris.ac.uk/motm/motm.htm

- Discuss ethanoic acid as a weak acid and the reactions of this acid, including esterification. Illustrate the formation of esters using a class experiment (Activity 10.5 *Making esters from alcohols and acids*).

Common misunderstandings and misconceptions

There are misconceptions with this topic because the structures involved are getting more complex and they need to be practised frequently to ensure understanding. This topic also helps revise the earlier complex topic of weak acids.

Homework ideas

- Worksheet 10.4 *Organic acids and esters*
- Exercise 10.4 *Reactions of ethanoic acid*
- Coursebook questions 10.49 to 10.51 and End-of-chapter question 5

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Teaching ideas

Chapter 11 Petrochemicals and polymers

Syllabus sections covered: 14.2; 14.5; 14.8

Teaching resources

Syllabus section	Topic	40-minute periods	Resources in Coursebook	Resources in Workbook	Resources on this CD-ROM
14.2	Petroleum	4	Section 11.1 Activity 11.1 Fractional distillation of petroleum Activity 11.2 Cracking hydrocarbons Questions 11.1 to 11.4 EOCQs 2, 3 Animations on CD-ROM: Why is crude oil so useful?; How can we separate crude oil?; What is made when we burn fuels? Internet animations, linked from CD-ROM: Fractional distillation of petroleum (crude oil)	Exercise 11.1 Essential processes of the petrochemical industry Exercise 11.8 Meeting fuel demand Exercise 11.9 Smooth running	Worksheet 11.1 Distillation of petroleum and cracking
Introduction	Alternative fuels and energy sources	1	Section 11.2 Activity 11.3 Comparing fuels EOCQ 1		Worksheet 11.7 Ethanol production
14.5; 14.8	Addition polymerisation	4	Section 11.3 Activity 11.4 Comparing different plastics Questions 11.5 to 11.9 Animation on CD-ROM: Why is poly(ethene) so useful?	Exercise 11.2 Addition polymerisation Exercise 11.3 the structure of man-made fibre molecules	Worksheet 11.2 Addition polymers Worksheet 11.4 Addition polymers and their uses

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Syllabus section	Topic	40-minute periods	Resources in Coursebook	Resources in Workbook	Resources on this CD-ROM
14.5; 14.8	Condensation polymerisation	5	Section 11.4 Activity 11.5 The nylon rope trick Activity 11.6 Chromatography of amino acids Questions 11.10 to 11.14 EOCQs 4, 5 Internet animations, linked from CD-ROM: Addition and condensation polymers	Exercise 11.4 Condensation polymerisation Exercise 11.5 The analysis of condensation polymers Exercise 11.6 Representing condensation polymerisation reactions Exercise 11.7 Small-scale molecular engineering	Worksheet 11.3 Condensation polymers Worksheet 11.5 Skin allergies Worksheet 11.6 Enzymes in industry

Topic 1 Petroleum

Coursebook section 11.1 (pp. 275–282)

Teaching ideas

- Outline the process of fractional distillation of petroleum (crude oil), detailing the different fractions obtained and uses for each fraction. The 'Alchemy' resource from the Royal Society of Chemistry (UK) gives details and resources on a series of industrially important processes including 'oil refining' and the making of polythene and nylon: http://www.rsc.org/Education/Teachers/Resources/Alchemy/
- Discuss the need for cracking of the longer-chain fractions from oil refining and consider various examples. Comment on the usefulness of all the products from the cracking process.

Common misunderstandings and misconceptions

There are few misconceptions here but the complexity of the cracking process requires clear discussion, with straightforward examples being established before the more complicated possibilities are discussed. Note that the syllabus clearly states hydrogen as a possible product of the cracking process.

Homework ideas

- Coursebook questions 11.1 to 11.4 and End-of-chapter questions 2 and 3
- Worksheet 11.1 *Distillation of petroleum and cracking*
- Work through Exercise 11.1 *Essential processes of the petrochemical industry*, Exercise 11.8 *Meeting fuel demand* and Exercise 11.9 *Smooth running*. These cover the processes of the industry and the economic demands on the industry.

Topic 2 Alternative fuels and energy sources

Coursebook section 11.2 (pp. 282–284)

Teaching ideas

- Class discussion of alternative fuels could usefully take place here, to include topics such as biogas.
- There are various practical activities suggested here to reinforce the class discussions (e.g. Activity 11.3 *Comparing fuels* and Exercise 10.6 *The chemistry of butanol*).
- Discuss the economics of why, apart from the overall environmental concerns, it is advantageous for certain countries to develop alternative fuels.

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Common misunderstandings and misconceptions

There are few misconceptions associated with this topic.

Homework ideas

- Worksheet 11.7 *Ethanol production*

Topic 3 Addition polymerisation

Coursebook section 11.3 (pp. 284–287)

Teaching ideas

- Discuss the process of the addition polymerisation of ethene and then develop the ideas using other examples. Molecular models can be helpful here and students need to become familiar with the different ways of representing this form of polymerisation as an equation.
- Paper clips or pop-it beads can be used to illustrate the definition of monomers and a polymer.
- It is useful to have a stock of examples of articles made from different polymers to help clarify the uses of the different forms.
- Discuss the non-biodegradability of these man-made polymers and the issues related to this.

Common misunderstandings and misconceptions

There are few misconceptions here but students will need practice at the equations that represent the polymerisation process.

Homework ideas

- Worksheet 11.2 *Addition polymers* and Worksheet 11.4 *Addition polymers and their uses*
- Exercise 11.2 *Addition polymerisation* and Exercise 11.3 *The structure of man-made fibre molecules*
- Coursebook questions 11.5 to 11.9
- Students could also carry out research into the history of polymers. This could look at naturally occurring polymers that humans have used for thousands of years to breakthroughs in polymer and plastic technology during the twentieth century.

Topic 4 Condensation polymerisation

Coursebook section 11.4 (pp. 287–292)

Teaching ideas

- Introduce the idea of condensation polymers. Emphasise the biological importance of this form of polymerisation. Focus on the biological polymers such as starch and proteins.
- Discuss the different polymers and their structure using the representational form shown in the syllabus – possibly start with starch first as the simplest to visualise.
- After discussing proteins, introduce the man-made fibre nylon and point out the similarity of its structure to that of a protein chain. Also point out the difference in structure between proteins and nylon. Demonstrate the nylon-rope experiment showing the formation of the polymer.
- Students could also make 'slime'. It uses an existing polymer (PVA) and borax. The borax molecules create cross-links between the long chains of PVA thus creating a new polymer. Students can add colour to their slime and keep it in a plastic sandwich bag for several weeks.
- Discuss the hydrolysis of condensation polymers, such as proteins and starch, and the subsequent analysis by chromatography.
- Revisit esters as molecules formed by a condensation reaction and introduce the idea of polyesters, and *Terylene* in particular. Again, develop the schematic representation of the formation of this polymer.
- Some additional experiments relating to polymer formation can be found at: www.practicalchemistry.org

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Common misunderstandings and misconceptions

This is a complex topic and students need to be thoroughly practised in the use of the schematic ways of representing the different examples of polymerisation and the structures formed.

Homework ideas

- Worksheet 11.3 *Condensation polymers*
- Exercise 11.4 *Condensation polymerisation*, Exercise 11.5 *The analysis of condensation polymers* and Exercise 11.6 *Representing condensation polymerisation reactions*
- Worksheet 11.5 *Skin allergies* and Worksheet 11.6 *Enzymes in industry* approach parts of this topic from a novel direction.
- Exercise 11.7 *Small-scale molecular engineering* also places questions from the syllabus in a novel context to help the students in applying their knowledge and understanding to unusual material.
- Coursebook questions 11.10 to 11.14 and End-of-chapter questions 4 and 5 are useful in this context.

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Teaching ideas

Chapter 12 Chemical analysis and investigation

Syllabus sections covered: 8.4; 2.2.1; 14

Teaching resources

Syllabus section	Topic	40-minute periods	Resources in Coursebook	Resources in Workbook	Resources on this CD-ROM
8.4	Inorganic analysis	12	Section 12.1 Activity 12.1 Analysing the make-up of a compound Activity 12.2 Identifying an unknown mixture Activity 12.3 An observation exercise Questions 12.1 to 12.9 EOCQs 1, 2, 10 Internet animations, linked from CD-ROM: Collection of gases; Analysis	Exercise 12.1 Titration analysis Exercise 12.2 Chemical analysis	Worksheet 12.1 Identifying salts Worksheet 12.4 Sodium metabisulfite Worksheet 12.5 Silver halides
14.5; 14.7; 14.8	Organic analysis	2	Section 12.2 Questions 12.10 to 12.12 EOCQ 5		Worksheet 12.3 Finding the formula of an organic acid by titration
	Experimental design and investigation	12	Section 12.3 Questions 12.13 to 12.14 EOCQs 3, 4, 6, 7, 8, 9	Exercise 12.3 Planning a controlled experiment Exercise 12.4 Chemical testing and evaluation Exercise 12.5 Experimental design	Worksheet 12.2 The efficiency of fertilisers
	How practical work is assessed		Section 12.4 Two Model Papers 6 on CD-ROM		

Topic 1 Inorganic analysis

Coursebook section 12.1 (pp. 296–304)

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Teaching ideas

Outline the tests for gases specified by the syllabus – now including sulfur dioxide. Outline and explain the rationale of the analytical tests for the positive and negative ions occurring in salts. Discuss certain additional tests – for water, for example – and general methods for handling gases.

- The content of this chapter requires a somewhat different approach to the other chapters in that practical work is ongoing throughout the whole course. As such, the aspects that are key to the practical assessment will be taught, revised and reinforced at a series of different points during the whole course. To assist with that, a range of resources is listed here that can be drawn on at these various points.
- Knowledge of the analytical tests is of substantial importance since students can be questioned about them, not simply in their practical assessment, but also on the written papers (1, 2, 3 or 4). Students should be aware of two aspects of any particular test: a description of the test itself and the expected positive outcome. It is also worth stressing to students that, if they are asked to compare the results of a test on two substances, one positive the other negative, then they should comment on both the positive result and the negative result to give a thorough answer and gain all the marks for the question.
- Activity 12.1 *Analysing the make-up of a compound*, Activity12.2 *Identifying an unknown mixture* and Activity12.3 *An observation exercise* give practical exercises that reinforce familiarity with some aspects of applying the analytical tests.

Common misunderstandings and misconceptions

Familiarity and practice are the important factors for the successful understanding of this area of chemistry. The two most difficult aspects of the tests are perhaps the distinction between aluminium and zinc ions using alkali and recognising the test for nitrate ions as opposed to that for ammonium ions.

The new syllabus also includes a further example of a cation that can be distinguished by its behaviour in excess alkali. However, the chromium(III) ion produces distinctively coloured precipitates and solutions with sodium hydroxide and aqueous ammonia.

Homework ideas

- Use the examples given in the end-of-chapter questions, the Model examples of Paper 6 and the exercises in the Workbook to familiarise students with the types of question they will meet in the examination.
- Worksheet 12.1 *Identifying salts*, Worksheet 12.4 *Sodium metabisulfite* and Worksheet 12.5 *Silver halides* explore the use of the analytical tests to identify compounds, including some aspects that are new to the syllabus.
- Use the examples from past papers available on the University of Cambridge International Examinations IGCSE Teacher's Support website. Students also have access to some papers through the student support website: http://www.cie.org.uk/cambridge-for/learners-and-parents/study-resources/

Topic 2 Organic analysis

Coursebook section 12.2 (pp. 304–305)

Teaching ideas

- Introduce tests for unsaturated hydrocarbons and the characteristics of compounds such as ethanol, ethanoic acid and esters.
- Students should be aware of two aspects of any particular test: a description of the test itself and the expected positive outcome. It is also worth stressing to students that, if they are asked to compare the results of a test on two substances, one positive the other negative, then they should comment on both the positive result and the negative result to give a thorough answer and gain all the marks for the question.
- Knowledge of the analytical tests is of substantial importance since students can be questioned about them, not simply in their practical assessment, but also on the written papers (1, 2, 3 or 4).

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Common misunderstandings and misconceptions

There are no substantial misunderstandings or misconceptions here. The main difficulty lies in students failing to give sufficiently comprehensive answers to questions in the tests. Stress the need to give the colour before and after the test when describing a colour change. Also stress the need to describe the negative result when comparing, say, the result of the bromine water test on an alkane and alkene.

Homework ideas

- Coursebook questions 12.10 to 12.12, p. 305 and End-of-chapter question 5 indicate the type of question that can be asked on testing for organic substances.

Topic 3 Experimental design and investigation

Coursebook section 12.3 (pp. 305–310)

Teaching ideas

- In the early stages of the course, use questioning to find out the learners' current understanding of what these measurements mean, and what units are involved. Possibly play a game of 'Name that apparatus' in small teams of students. Provide students with a number of challenges to help them choose the most appropriate equipment to measure a certain amount., e.g. 'Bring me 20 ml of water', 'Bring me 1 g of salt', etc.
- Students practise using the equipment with a 'circus' of activities to include measurements of temperature, volume, mass and time in the laboratory.
- Provide guidance and opportunities for the design, investigation and evaluation of practical activities.
- The comments made earlier in the notes for this chapter are again relevant.

Common misunderstandings and misconceptions

The most common errors when handling measuring equipment in the laboratory include:

- time recorded in minutes and seconds, rather than seconds only
- correct use and positioning of a decimal point when measuring small masses in grams
- understanding the graduations on thermometers, burettes and measuring cylinders
- selecting a beaker rather than a measuring cylinder for recording volumes – students need general guidance on the relative accuracy of graduated glassware
- general misuse of correct units.

Students find the area of planning and evaluating experiments difficult – often resorting to very generalised comments about 'fair testing'. The ideas involved should be broached and developed over an extended period. To assist with this, a range of resources is listed here which can be drawn on at these various points during the course.

These are areas of practical work that students can find rewarding. However, they may detract from their achievement by lazy and unskilled presentation of diagrams, tables and graphs. The exercises in the Workbook coupled with the self-assessment tables given there are intended to help students to be more disciplined in these areas.

The use of IT packages to assist with data logging and presentation is one area that may generate additional interest in students and help with the evaluation of data. However, it should be remembered that students will have to work 'by hand' in examinations, so they cannot leave aside the development of these skills.

Homework ideas

- Use the examples given in the end-of-chapter questions, the Model Paper 6s and the exercises in the Workbook to familiarise students with the types of question they will meet in the examination.
- The exercises presented in Chapter 12 of the Workbook are specifically designed to cover the type of questions on planning and evaluation that can now occur on both the practical papers (Papers 5 and 6) of the exam: Exercises 12.3 *Planning a controlled experiment*, Exercise 12.4 *Chemical testing and evaluation* and Exercise 12.5 *Experimental design*.

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- Use the examples from past papers available on the University of Cambridge International Examinations IGCSE Teacher's Support website. Students also have access to some papers through the student support website: http://www.cie.org.uk/cambridge-for/learners-and-parents/study-resources/

Topic 4 How practical work is assessed

Coursebook section 12.4 (pp. 310–325)

Teaching ideas

Use the material presented in this section of the Coursebook to prepare students for the practical component of their examination. A broad and detailed experience of practical work and the techniques involved is the best and most thorough preparation for success in this area of the course.

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Worksheet 1.1

What use is chemistry?

Over the past 100 years, chemistry has transformed the lives of many people in different parts of the world. Our world society has been made totally different from how it was in the early 1900s by the availability of a great number of new products, materials and processes. Chemistry has provided the solution to some major problems that have faced the expanding world population. For instance, there are those who argue that the most significant scientific discovery of the twentieth century was Haber's process for the synthesis of ammonia, generating, as it did, the possibility of feeding the world's expanding population.

The distribution of the benefits is not even-handed, but what would life be like without shampoo and conditioner, shower gel and bubble bath, antiperspirants and deodorants, man-made fibres such as nylon and *Terylene*, brilliantly coloured dyes, lightweight tennis rackets, modern 'trainers' and other sports equipment, most make-up, detergents? Without our increased knowledge of chemistry, there would be no inorganic fertilisers (80% of the world would starve), no purified water, no aspirin, paracetamol or ibuprofen, no penicillin or other antibiotics, no anaesthetics, no modern glues and adhesives (your furniture would fall apart!), no contraceptives, no house paint. Even in just the last few years, chemistry research has led to the development of flat screen televisions and monitors, smaller mobile phones (by improving battery technology) and scratch-resistant phone covers.

Think about the contribution that chemistry has made to our lives as you do one of the following activities.

1 Make a collage using pictures from old magazines, catalogues and other pictures to show the changes that chemistry has made to our lives in the last century or so. Try to find lots of pictures of things that would not exist without the contribution of modern chemistry.

2 Write about how your daily life would be different without all the things that chemistry has helped to provide. Consider these different aspects: what you wear, what you eat, your leisure activities and what happens if you get ill.

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Worksheet 1.2

Combustion

1 Complete these sentences using the words below to fill the gaps.

combustion **oxygen** **react** **nitrogen** **oxides**

The air is roughly four-fifths …….. and one-fifth

…….. When things burn, they ……..with

the oxygen present in the air. New chemical compounds called ……..

are formed, and energy is given out. The scientific word for burning is

……..

2 **a** When carbon burns completely in air, it forms the colourless gas carbon dioxide.

Complete the word equation for this reaction.

carbon + …….. → ……..

b **iii** When hydrogen burns, it forms hydrogen oxide vapour.

What is the common name we give to this new chemical?

…….

ii Complete the word equation for this reaction.

hydrogen + …….. → ……..

c The apparatus shown in the diagram can be used to identify the gases produced when a candle burns.

The following comments are useful in understanding the experiment:

- Candle wax contains carbon and hydrogen.
- The waste gases rise into the funnel.
- The waste gases are drawn through the apparatus by the pump.
- The crushed ice cools the gases.
- A colourless liquid condenses and collects.
- The remaining gas bubbles through limewater.
- The limewater turns milky.
- The colourless liquid turns white anhydrous copper sulfate powder blue.

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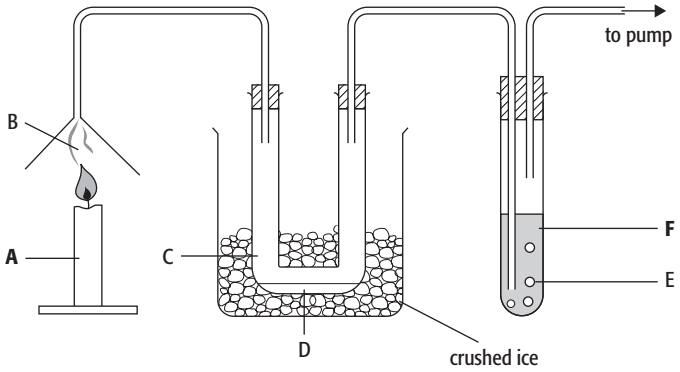

What do the labels **A** to **F** represent in the diagram?

A = …… **B** = ……

C = …… **D** = ……

E = …… **F** = ……

3 Carbon monoxide alert

Every year in the United Kingdom more than 50 people are killed, and a further 150 people are hospitalised, by a simple gas formed during the inefficient burning of carbon-containing fuels such as gas, wood, oil and paraffin. This gas is carbon monoxide.

The aim here is for you to do some research to find out about this deadly gas and then present your findings as a warning poster or leaflet. You can choose the target audience of your leaflet or poster.

Your leaflet or poster

Your leaflet or poster should be aimed at one of these groups of people:

- students
- the elderly
- families with young children.

What you need to find out

- How and under what circumstances is carbon monoxide formed?
- Why is this gas poisonous – what effects can it have and what are the symptoms to look out for?
- Which group of people is most at risk?
- How can carbon monoxide poisoning be cured?
- How can carbon monoxide poisoning be prevented?

The following websites may be good places to start your search:

- http://www.hse.gov.uk/gas/domestic/co.htm – this is a UK government website
- www.carbonmonoxidekills.com
- www.howstuffworks.com – you should enter a search for 'carbon monoxide' at this site.

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Worksheet 1.3

Clean energy using hydrogen

Prepare notes for a class discussion on the benefits of hydrogen as a source of energy, particularly for cars and vehicles. Use the following website as a source of information:

http://www.bmweducation.co.uk/cleanenergy/

Consider particularly the following questions:

- Why is hydrogen said to be a 'clean' energy source?
- What other advantages does hydrogen have?
- What are the difficulties associated with using hydrogen as an energy source?
- What **two** different ways can hydrogen be used to power cars?

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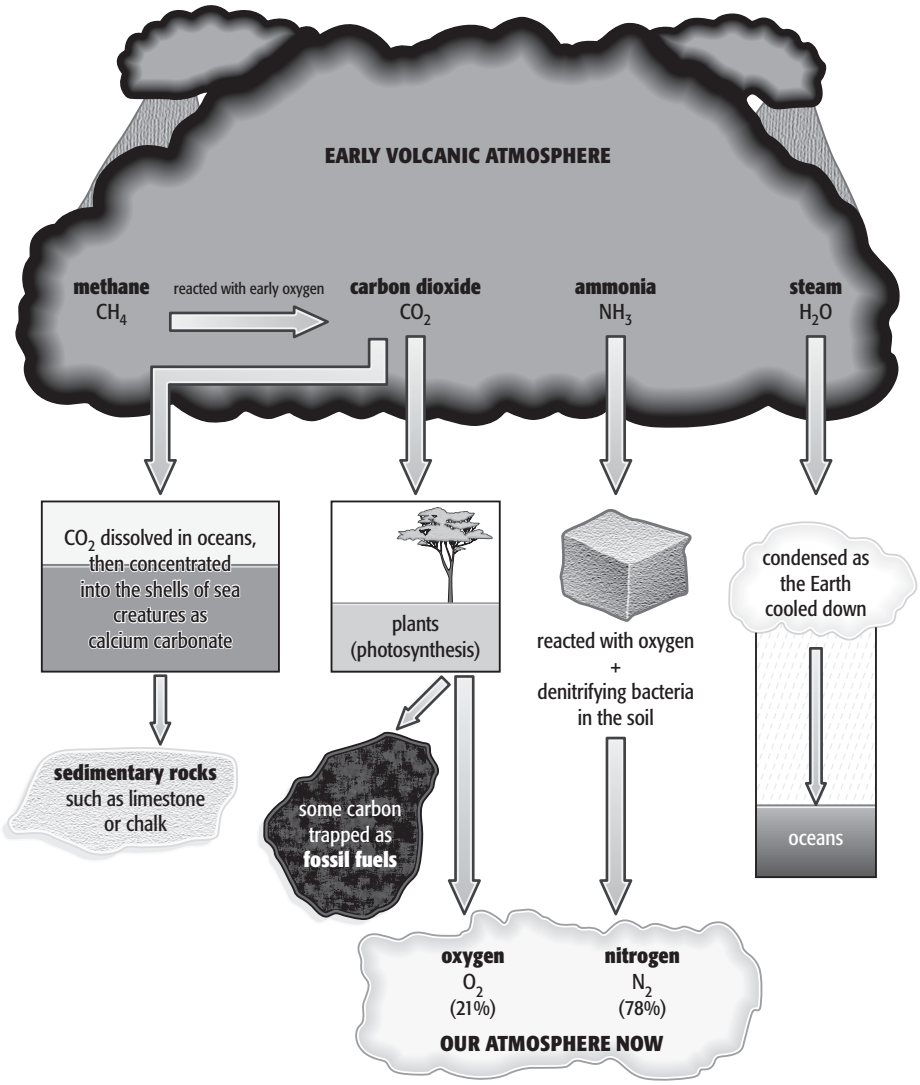
Worksheet 1.4

What happened to all the carbon dioxide?



The early atmosphere of the Earth was rich in carbon dioxide. This carbon dioxide did not just vanish into nowhere. All the carbon is still stored in the Earth.

Much of the carbon dioxide was used by plants in photosynthesis to make food which in turn formed their structure. Some of the plants were eaten by animals and the carbon became part of their structure.

When these living things died, they often became buried by sediment at the bottom of swamps, lakes and seas. Here they slowly changed due to heat and pressure and became the fossil fuels we know today: coal, petroleum and natural gas.

Carbon dioxide dissolved in the water of seas was also used by shellfish to build their shells. These shells are made from calcium carbonate. The shells together with corals, also made from calcium carbonate, slowly changed over time into the sedimentary rock limestone.

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Limestone is one of the most common rocks in the Earth's crust. It is found all over the world from the bottom of the deepest sea to the top of the highest mountain. The fossil remains of shells and corals can often still be seen in it.

This worksheet is concerned with how we use one of these carbon-containing, raw materials.

Limestone

Limestone has many uses. It is used as it is for building and it is chemically changed to make cement, lime, glass and many other chemicals. It is also used in the extraction of iron in the blast furnace. In many of these uses, some of the carbon dioxide is released back into the air.

Why is this a problem?

When limestone is heated, this reaction takes place:

$$\underset{\text{limestone}}{\text{calcium carbonate}} \xrightarrow[\text{HEAT}]{} \underset{\text{lime}}{\text{calcium oxide}} + \text{carbon dioxide}$$

Lime is used in the making of steel. Lime reacts with water and the reaction produces a great deal of heat.

$$\underset{\text{lime}}{\text{calcium oxide}} + \text{water} \rightarrow \underset{\text{slaked lime}}{\text{calcium hydroxide}}$$

Slaked lime is used by farmers to treat soil which is too acidic.

The reaction of lime with water is used in self-heating food and drink cans where the can itself heats the contents when opened.

Heating limestone with clay makes cement. Mixing cement with sand and water makes concrete.

Millions of tons of limestone are extracted from the ground each year by digging quarries. Local residents often complain about the dust, noise and the destruction of beautiful scenery.

Using the information given above, list the good things and the bad things about removing limestone from the Earth.

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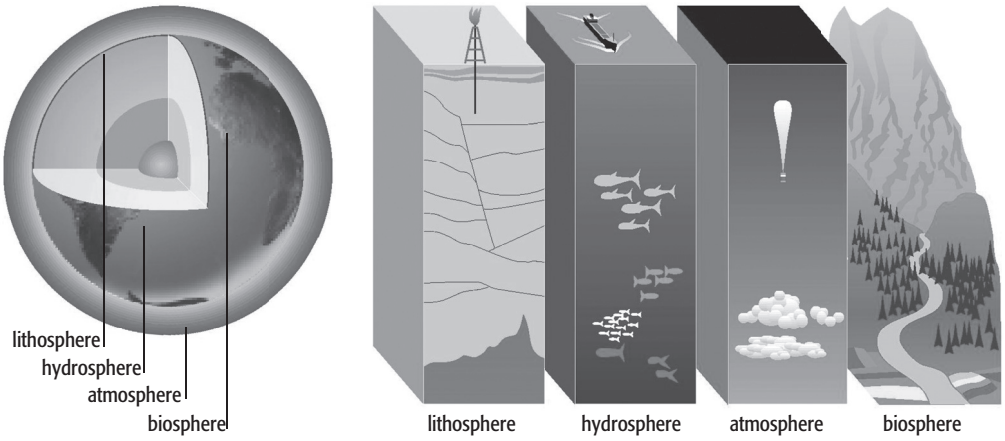
Worksheet 1.5

The chemistry of the Earth's layers



When discussing the chemistry of the Earth, it is often useful to divide it into four sections or 'spheres'. These surface layers are:

- the **lithosphere** – this consists of the solid rock and soil component of the crust and upper mantle
- the **hydrosphere** – the water on, in and around the Earth
- the **atmosphere** – the gases surrounding the Earth
- the **biosphere** – the living things on the Earth.

The detailed chemistry of each of these areas is complex, but the following very broad generalisations are sometimes made.

1 The chemistry of the lithosphere is essentially that of **giant ionic structures**.

2 The hydrosphere consists of **small molecules with dissolved ions**.

3 The atmosphere is made up of **simple molecular substances**.

4 The biosphere involves the chemistry of **long-chain condensation polymers**.

The lithosphere

1 Give the chemical names for the following mineral resources found in the Earth's crust.

a hematite .....

b bauxite .....

c limestone .....

d common salt .....

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2 Complete the following table by giving the chemical formula of the minerals listed.

Mineral	Chemical name	Ions present	Chemical formula
malachite	copper(II) carbonate	Cu^{2+} and CO_3^{2-}	
galena	lead(II) sulfide	Pb^{2+} and S^{2-}	
quartz	calcium silicate	Ca^{2+} and SiO_3^{2-}	
bauxite	aluminium oxide	Al^{3+} and O^{2-}	
cryolite	sodium aluminium fluoride	Na^{+} and AlF_6^{3-}	

3 Galena (lead(II) sulphide) forms cubic crystals similar in structure to those of sodium chloride. Sketch the arrangement of the lead ions and sulphide ions in such a cubic crystal.

Use the symbol ● for the Pb^{2+} ions and ○ for the S^{2-} ions.

The hydrosphere

The oceans and seas cover about 72% of the Earth's surface. They contain 97% of the available water on the planet. However, this is not drinking water as it contains, on average, about 3.5% dissolved solids. The most obvious of these dissolved salts is sodium chloride but there are others present. The table below shows the ten commonest ions present in seawater.

Positive ions	Concentration / mol/dm³
sodium	0.46
magnesium	0.06
calcium	0.01
potassium	0.001

Negative ions	Concentration / mol/dm³
chloride	0.54
sulfate	0.03
carbonate	0.002
bromide	0.0008
borate	0.0003
silicate	0.0001

Answer the following questions using information from the table.

1 From which **two** groups of the Periodic Table do all the metal ions come? Suggest why this is so.

.....

.....

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2 What elements are present in the borate ions? Explain how the name tells you what elements are present.

.....

.....

.....

3 Which ion, Na+ or Cl^-, is present in excess in seawater? Therefore what is the effective concentration of sodium chloride in seawater?

.....

.....

.....

.....

4 What is the maximum mass of sodium chloride that could be extracted from 1 dm^3 of seawater?

.....

.....

.....

5 'Sea salt' is sometimes recommended for cooking. Apart from sodium chloride, what other metal chloride is most likely to be found in 'sea salt'?

.....

Variations in the saltiness of different seas

Although, on average, the % of dissolved solids in seawater is 3.5, there is considerable variation in different parts of the world.

Location	Percentage of dissolved solids / %
open ocean	3.5
Mediterranean Sea	3.9
Red Sea (northern end)	4.1
Dead Sea	27.0

1 What sort of climates do the Mediterranean Sea, the Red Sea and the Dead Sea have? What sort of geographical surroundings do they have? (You could use an atlas or an internet search to help you find this information.)

.....

.....

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2 Suggest why these seas (especially the Dead Sea) are saltier than the open ocean.

.....

.....

.....

.....

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Worksheet 1.6

Atmospheric anagrams

Anagrams are tricks played with the letters of words. The letters are rearranged to give words with a different meaning. They are often found in the clues to crossword puzzles.

For instance, two short scientific examples of anagrams in clues would be:

- Oddly, ***none*** gave this noble gas. (4)
- ***As yet*** the fermentation was incomplete. (5)

The letters involved in each anagram are in italics. Can you work these out?

Often it is useful to arrange the letters in a circle to jumble them a little and let you see the alternative words, for example:

A
T S YEAST
E Y

Human activity has resulted in changes in the gases present in the air. There are several major atmospheric problems arising from this pollution.

The names given to these problems are listed below in anagram form – where the letters have been mixed up. They range from problems in the upper atmosphere to one which occurs particularly in large cities. Also listed are some of the important terms used in talking about air pollution, together with the names of some of the chemicals involved.

Sort out the letters into the name or term used and write it in the space provided.

1 CAN I RAID .....

2 NEAT HEM .....

3 DIXIE CAN BROOD .....

4 GET CHANCE MAIL .....

5 DI, U FIX OUR SLED .....

6 GLOWING LAB ARM .....

7 ZOE PELTED ONION .....

8 SAGE HEN GROUSE .....

9 GIMME CHOCOLAT SHOP! .....

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Worksheet 1.7

Distillation of liquid air

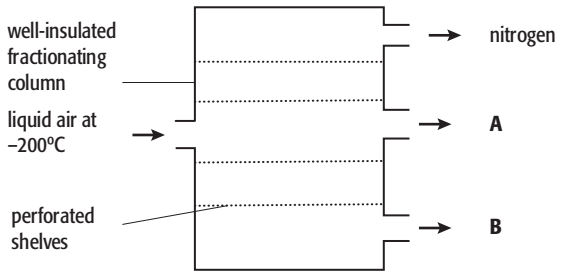
1 The table below shows the percentage and the boiling point of the three main elements in **liquid air**.

Element	Percentage / %	Boiling point / °C
argon		−186
nitrogen	78	−196
oxygen		−183

a Complete the table.

b Name the gas with the **highest** boiling point. .....

2 The following diagram shows the fractionating column for separating liquid air into argon, nitrogen and oxygen.



a Name this method of separation. .....

b Name gas **A**. .....

c Name gas **B**. .....

3 Name **two** gases which are present in the atmosphere but **not** in liquid air.

.....

4 Give **one** use of:

a argon .....

b nitrogen .....

5 Explain how oxygen is used in the steel industry.

.....

.....

.....

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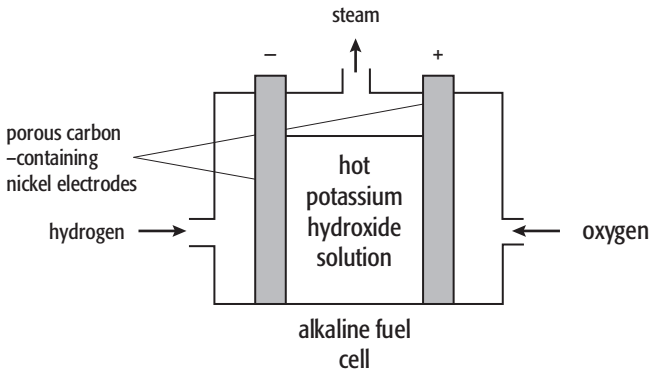
Worksheet 1.8

Fuel cells

Fuel cells are often taken into space to supply energy. They turn the energy of a fuel directly into electricity.



1 **a** Why are fuel cells of this type often referred to as 'alkaline fuel cells (AFC)'?

.....

b Why are porous electrodes needed in a fuel cell?

.....

c Why is nickel included in the electrodes?

.....

2 What is the main way in which fuel cells differ from other electrochemical cells?

.....

3 Write an equation for the overall reaction taking place in a fuel cell.

.....

4 Give **two** reasons why fuel cells are more suitable than dry cells for use in spacecrafts.

.....

.....

5 What other type of cell could be used in a spacecraft?

.....

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Worksheet 1.9

Catalysts in cars

A research laboratory is investigating the effectiveness of various catalysts for the reduction of pollution in petrol-powered car exhausts.

They have devised their own units for measuring air pollution called apus (atmospheric pollution units). The table below shows their results comparing several different catalysts which would be suitable for fitting into catalytic converters.

Catalyst	Unburnt petrol / apu	Carbon monoxide / apu	Oxides of nitrogen / apu
none	100	700	500
A	30	150	150
B	50	250	300
C	10	75	90

1 In his lab notebook, the research scientist uses the abbreviations 'CO', 'NO_x' and 'unburnt HC'. What do these abbreviations stand for?

a CO .....

b NO_x.....

c unburnt HC .....

2 **a** Which catalyst is most effective at reducing total pollution?

.....

b Which is the largest pollutant in the exhaust before a catalyst is used?

.....

c Which is the largest pollutant in the exhaust from the most effective catalyst?

.....

d What types of metal are usually used as catalysts in catalytic converters?

.....

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3 The metal catalyst is coated on to a honeycombed ceramic support. It works best when the engine has warmed up.

a Explain why a honeycombed support is better than a solid one.

.....

b Explain why the catalyst works better when the engine is warm.

.....

4 Heavy metals may stick to the catalyst and prevent it from working. The catalyst is said to be 'poisoned'.

a Explain how catalysts work and how poisoning with heavy metals prevents this.

.....

.....

.....

b Why should the owners of cars with catalytic converters always use unleaded petrol?

.....

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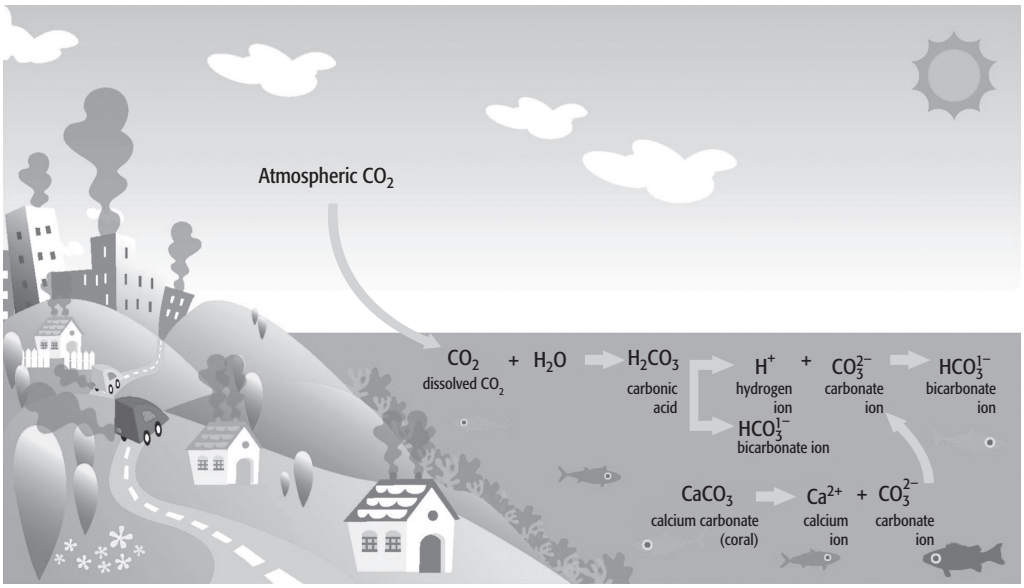
Worksheet 1.10

The acidification of the oceans



The diagram shows how atmospheric carbon dioxide dissolves in the oceans and the products formed. The dissolved CO_2 is of great importance for the balance of life in the oceans, particularly for many organisms, most notably coral, plankton and various types of seaweed.

Use information from the diagram to answer the following questions.

1 What are the name and formula for the acid formed when carbon dioxide dissolves in water?

.....

2 The diagram refers to the bicarbonate ion, HCO_3^-. What is the more technically correct name for this ion now?

.....

3 The acid formed when carbon dioxide dissolves in water is only a weak acid. What does the term **weak acid** mean?

.....

4 The ionisation of the acid involves the following reaction:

$H_2CO_3(aq) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$

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a What does the symbol ⇌ mean?

.....

b What does the notation **(aq)** mean after a formula in an equation?

.....

5 An environmental problem of increasing significance is that of **ocean acidification**. The pH of the ocean surface has already fallen 0.1 units, representing a 30% increase in acidity. By the end of this century, if current emission trends continue, it could fall by another 0.3 units, an almost 100% increase in acidity.

A neutral solution has a pH of 7 and clean seawater has a pH ranging from pH 8 to 8.3. In discussing this, it is important to understand the pH scale: each unit change means a 10× increase or decrease in acidity so, for example, pH 5 is 10 times more acidic than pH 6 and 100 times more acidic than pH 7.

Concentrations of hydrogen ions compared to distilled water (pH)		Examples of solutions and their respective pH
10,000,000	0	battery acid
1,000,000	1	hydrochloric acid
100,000	2	lemon juice, vinegar
10,000	3	orange juice, soda
1,000	4	tomato juice
100	5	black coffee, acid rain
10	6	urine, saliva
1	7	"pure" water
1/10	8	seawater
1/100	9	baking soda, toothpaste
1/1,000	10	milk of magnesium
1/10,000	11	household ammonia
1/100,000	12	soapy water
1/1,000,000	13	bleach, oven cleaner
1/10,000,000	14	liquid drain cleaner

a Which positive ion does the pH measure the concentration of? Give its name and formula.

.....

b In neutral distilled water, the concentration of this ion is equal to the concentration of a negative ion that is produced in water. What is the name and formula of this negative ion?

.....

c Using information given in the table, how many times less acidic is tomato juice than lemon juice?

.....

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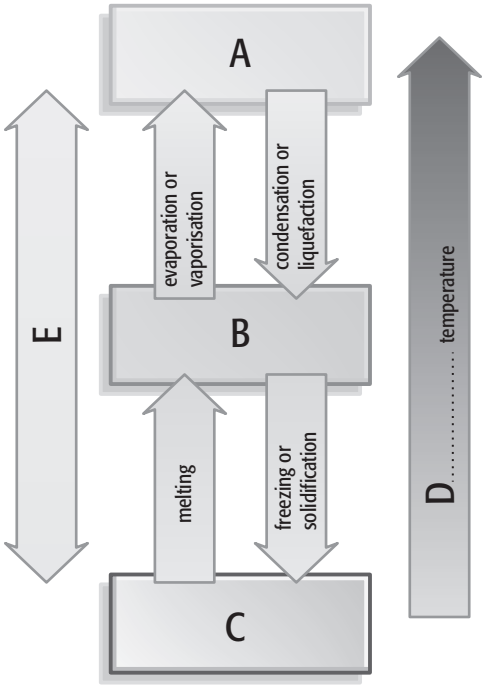
Worksheet 2.1

States of matter

1 **a** Complete the diagram by deciding the words which complete the labels **A**, **B**, **C**, **D** and **E**.



A = …… **B** = ……

C = …… **D** = ……

E = ……

b What other change in physical conditions can bring about a change in state even if the temperature remains the same?

……

2 The table below shows how many grams of five different solids dissolve in 100 g of the solvents water, alcohol and trichlorethene (all at 20 °C).

Solvents	Solids				
	salt	sugar	iodine	chalk	urea
water	36.00	204.00	0.03	0.00	100.00
alcohol	0.00	0.00	20.00	0.00	20.00
trichlorethene	0.00	0.00	3.00	0.00	0.00

a Which solid dissolves best in water at 20 °C? ……

b Which is the best solvent for iodine? ……

c Which solid is insoluble in all three solvents? ……

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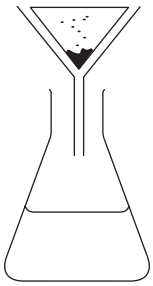
Worksheet 2.2

Separating mixtures

1 This apparatus can be used to separate a mixture of sand and salt.



a **i** What is this process called?

.....

ii What is the general name for the solid collecting in the funnel?

.....

iii What is the general name for the liquid which collects in the flask?

.....

b Write a set of instructions to show exactly how this separation should be done.

.....

.....

.....

.....

.....

.....

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c To complete the process, you will need to remove the salt from the water. Explain, using a diagram, exactly how this would be done and what the process is called.

2 Complete these sentences using the words below to fill the gaps.

compound **atoms** **different** **element** All substances are made from

…….. There are over 90 …….. kinds of atom. A

substance made from only one kind of atom is called an ……..

A substance made from two or more different types of atoms chemically bonded together is

called a ……..

3 **a** Rearrange these sentences to explain how water molecules behave in water vapour and how this turns to water as it cools. Copy the sentences out in the correct order.

At or below 100 °C, the particles stick together if they collide.

The water molecules in steam are far apart and moving very fast.

The steam condenses.

At temperatures above 100 °C, if the molecules collide, they simply bounce apart again.

Clumps of particles stick together and collect, forming liquid water droplets.

As the steam cools, the particles slow down.

……

……

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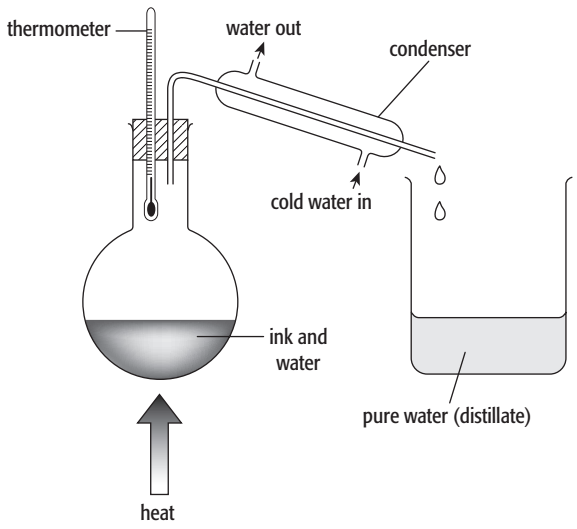
b The apparatus below is used to separate a mixture of two substances, such as water and ink dye.



i What is the name of this process?

.....

ii What is the purpose of the thermometer?

.....

iii What is the purpose of the cold water running through the outer jacket of the condenser?

.....

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Worksheet 2.3

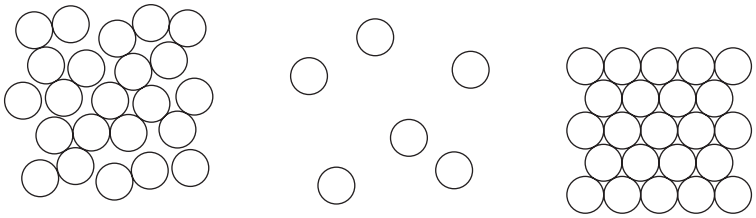
States of matter and the kinetic theory

1 Complete these sentences using the words below to fill the gaps.

gases **closer** **particles** **randomly** **solids** **compressed** Everything is made up of tiny …….. In …….. and liquids, these particles are close together, so solids and liquids cannot be …….. In …….. , these particles are far apart and moving …….. When a gas is compressed, the particles are pushed …….. together.

2 **a** The diagrams below show how the particles are arranged in solids, liquids and gases.

Label them correctly as solid, liquid or gas; and then answer the questions about the different states.



A B C

A = …… B = …… C = ……

b **i** Which state has the most ordered arrangement? ……

ii In which state is there the biggest distance between the particles? ……

iii In which state are the particles held firmly in place? ……

iv In which two states are the particles able to move from place to place? ……

v In which state are the particles the most free to move? ……

3 **a** By copying out the sentences below in a suitable order, explain how ice turns to water as it is heated.

As ice is heated, the particles vibrate faster and faster about their positions.

The ice melts.

At 0 °C, the particles are vibrating fast enough to start breaking the forces that hold them together.

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In solid ice, the particles are vibrating about fixed positions.

.....

.....

.....

.....

b Sulfur melts at 113 °C. Do you think the forces between sulfur particles are stronger or weaker than those between the water particles in ice? Explain your answer.

.....

.....

.....

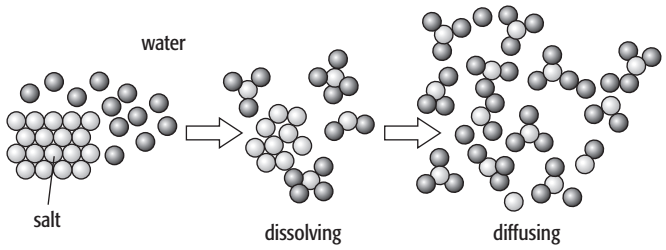
c Alcohol vapour condenses when the temperature drops below 78 °C. Do you think the forces between alcohol particles are stronger or weaker than those between water particles in water vapour? Explain your answer.

.....

.....

.....

d The diagram below shows how salt dissolves in water. Rearrange the four sentences below to describe how a salt dissolves in water.



Some of the surrounded outer salt particles break free from the crystal.

The salt and water particles diffuse away, allowing more salt particles from the next layer to be freed, and so on.

Water particles surround the salt crystal.

Water particles are attracted to the salt particles in the crystal and surround the salt particles.

.....

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Worksheet 2.4

Atomic structure

1 **a** Complete these sentences by deleting the incorrect word in each pair.

Atoms of the same element have the same number of **protons / neutrons**. The number of **protons / neutrons** in an atom is called its **proton / mass** number. The number of protons plus the number of **electrons / neutrons** in an atom gives the **atomic / nucleon** number. As an atom is neutral, the number of negative **electrons / neutrons** in an atom is always the same as the number of positive protons in the nucleus.

b Complete the following sentences using the words below to fill the gaps.

eight **electrons** **closest** **energy** **shells**

The ..... in an atom are not free to move where they like. They can only occur at fixed distances from the nucleus in electron ..... (or ..... levels).

The first shell, ... to the nucleus, can only take two electrons, while the second shell can take up to ..... electrons.

2 For each of these atoms of the following elements, give the proton number (atomic number) and the nucleon number (mass number).

a helium (He) has 2 protons, 2 neutrons and 2 electrons .....

b fluorine (F) has 9 protons, 10 neutrons and 9 electrons .....

c iron (Fe) has 26 protons, 30 neutrons and 26 electrons .....

d uranium (U) has 92 protons, 140 neutrons and 92 electrons .....

3 **a** Complete the table below to show the subatomic particles present in these atoms.

Element	Protons	Neutrons	Electrons	Nucleon number
Li		4		7
Na			11	23
P	15			31
Pb			82	207

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b Chlorine atoms come in two forms: $^{35}_{17}Cl$ and $^{37}_{17}Cl$.

i How do you know that they are both atoms of the same element?

.....

.....

ii What is the difference between the two types, or isotopes, of chlorine?

.....

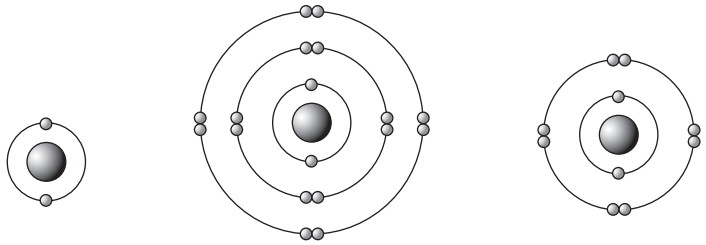
iii Which element is $^{14}_{6}X$ an isotope of?

$^{12}_{6}C$ $^{14}_{7}C$

Explain your answer.

.....

4



a Diagrams **A**, **B** and **C** represent the atoms of three elements. Name the elements.

A.....**B**.....**C**.....

b These elements are all very unreactive gases. What can be said about the electron arrangements of these atoms?

.....

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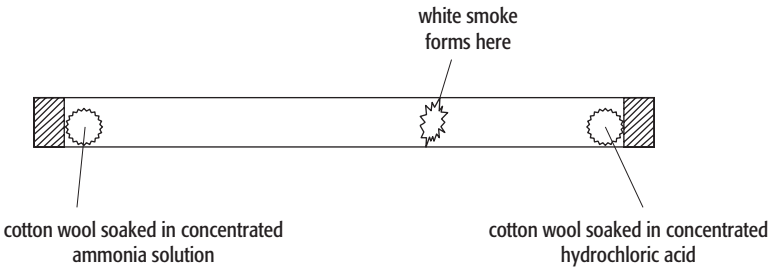
Worksheet 2.5

The motion of particles

The motion of particles can be demonstrated in a variety of ways.

The following experiment was carried out using concentrated ammonia solution and concentrated hydrochloric acid.


white smoke forms here
cotton wool soaked in concentrated ammonia solution
cotton wool soaked in concentrated hydrochloric acid

1 Ammonia contains the elements nitrogen and hydrogen and has the chemical formula NH_3.

a Name the type of bonding that exists in ammonia.

.....

b Draw a 'dot and cross' diagram to show the bonding in a molecule of ammonia. Only show the electrons in the outer energy level.

c Explain why ammonia has a low boiling point.

.....

.....

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2 The ammonia and hydrogen chloride gases meet and react to form the ring of white smoke as shown.

a Explain, in terms of the particles of the gases, why the gases meet.

.....

.....

b Explain why the ring of white smoke forms nearer to the concentrated hydrochloric acid.

.....

.....

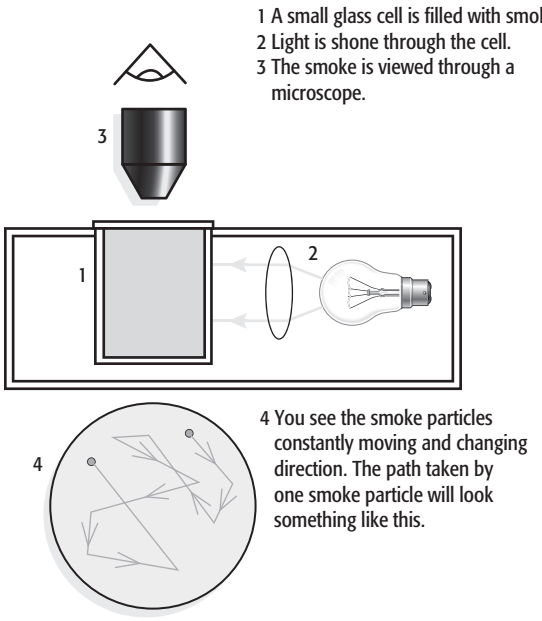
c What is the name of the chemical formed when ammonia and hydrogen chloride react? Write the word equation and chemical equation for the reaction.

.....

.....

.....

3 Some of the first evidence for the motion of particles in fluids came from the observations of Brownian motion. This can be observed using a smoke cell.


1 A small glass cell is filled with smoke.
2 Light is shone through the cell.
3 The smoke is viewed through a microscope.
3
1
2
4
4 You see the smoke particles constantly moving and changing direction. The path taken by one smoke particle will look something like this.

a Under the microscope, the smoke particles can be seen to moving in a jerky way. Their movement is thought to be an effect of the unseen movement of other particles. Explain what is causing them to seem to change direction randomly.

.....

.....

.....

.....

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b What is the name given to the movement of particles from place to place in fluids?

.....

c What type of movement are the particles in a solid allowed?

.....

.....

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Worksheet 2.6

Solubility rules!

Ours is a water world. Much important chemistry is that which can take place in water. Solubility is a key factor in this. The table below gives information about the solubilities of a number of salts.

	Sodium	Potassium	Lead	Barium	Calcium
Chloride	soluble	soluble	insoluble	soluble	soluble
Sulfate	soluble	soluble	insoluble	insoluble	slightly soluble
Nitrate	soluble	soluble	soluble	soluble	soluble
Carbonate	soluble	soluble	insoluble	insoluble	insoluble

1 What can you say about the solubility of sodium and potassium salts?

.....

2 What can you say about the solubility of nitrates?

.....

3 What can you say about the solubility of lead salts?

.....

4 Predict the products of the following reactions, underlining any precipitates:

a sodium carbonate solution with lead nitrate solution

.....

b calcium chloride solution with potassium nitrate solution – give the balanced chemical equation for this reaction

.....

c barium chloride solution with sodium sulfate solution – give the ionic equation for this reaction (including state symbols)

5 Barium salts are poisonous, yet some X-ray patients have to drink barium sulfate before examination. Explain why they can do this without harming themselves.

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Worksheet 3.1

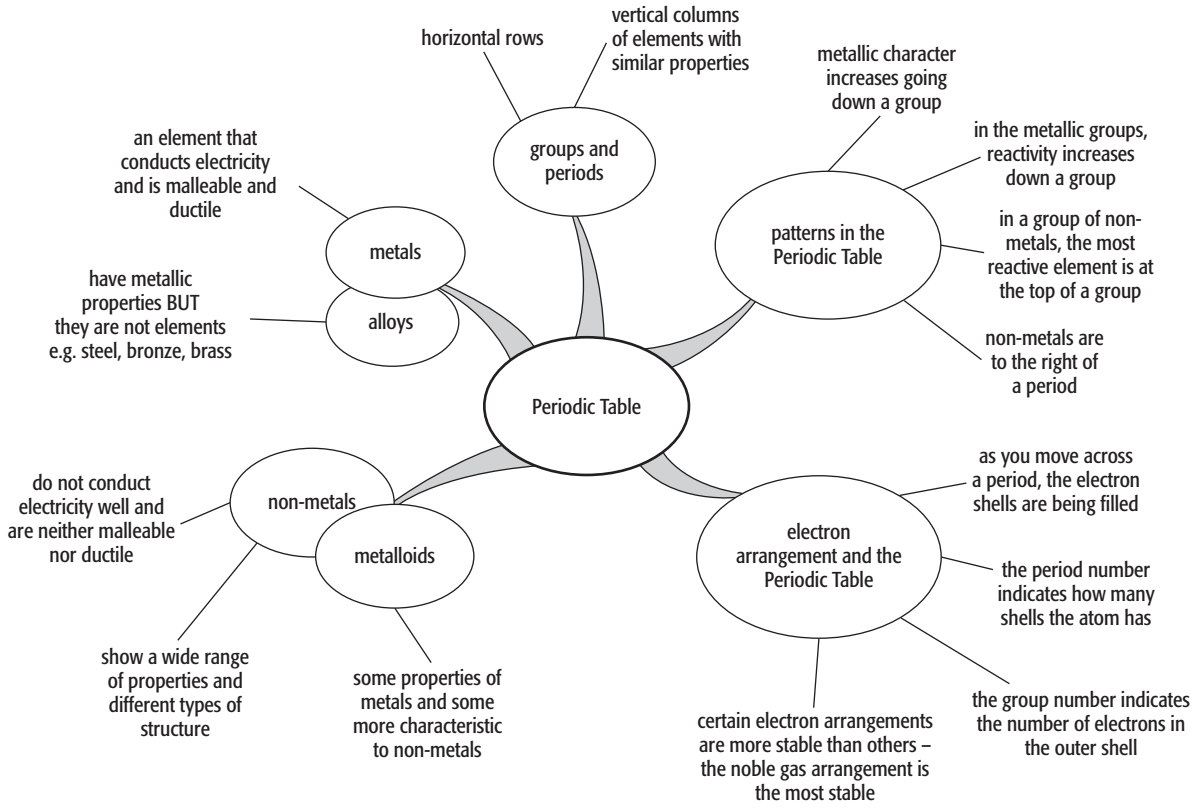
Mind mapping the Periodic Table

Mind mapping is a useful aid to thinking through a particular topic or section of a subject. It can help to show the links between different ideas in a subject and reinforce them in the mind.

This can be helpful in sorting through the complexity of a subject and as a memory and revision aid – it always helps to understand a subject area when learning it.

The mind map below was produced by a student dealing with the nature and connections involved in the structure of the Periodic Table and the information it contains.

Draw a mind map of your own on this subject area or a part of it, and judge for yourself whether it would be a useful revision aid for you.


Periodic Table
groups and periods
horizontal rows
vertical columns of elements with similar properties
metals
an element that conducts electricity and is malleable and ductile
alloys
have metallic properties BUT they are not elements e.g. steel, bronze, brass
patterns in the Periodic Table
metallic character increases going down a group
in the metallic groups, reactivity increases down a group
in a group of non-metals, the most reactive element is at the top of a group
non-metals are to the right of a period
non-metals
do not conduct electricity well and are neither malleable nor ductile
metalloids
show a wide range of properties and different types of structure
some properties of metals and some more characteristic to non-metals
electron arrangement and the Periodic Table
as you move across a period, the electron shells are being filled
the period number indicates how many shells the atom has
the group number indicates the number of electrons in the outer shell
certain electron arrangements are more stable than others – the noble gas arrangement is the most stable

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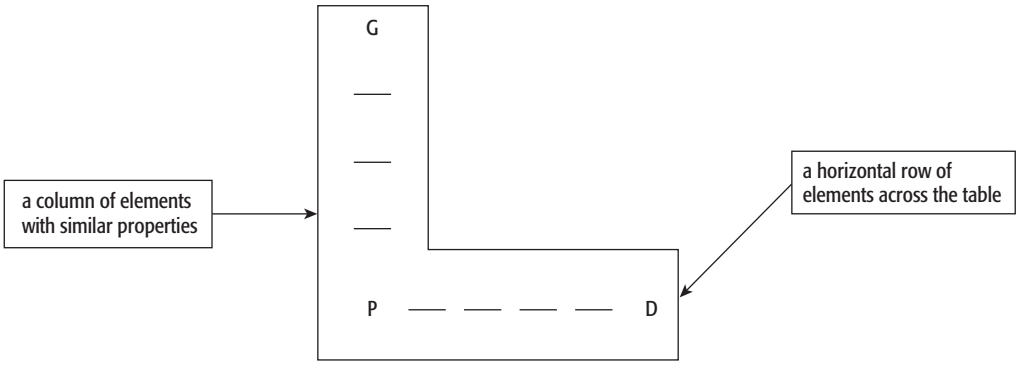
Worksheet 3.2

Patterns in the Periodic Table

1 Complete the sentences and diagram below.

Scientists look for patterns in data. Historically, when they arranged the known elements in order of relative ……., they found that there was a repeating pattern. These patterns were shown clearly when the elements were arranged in a …….. Each row in the table is called a period, with metals on the …….. and …….. on the right. The vertical columns of elements in the table were made up of elements with …….. properties.

Modern versions of the Periodic Table put the elements in order of …….. number, also known as the atomic number.



2 Complete the information below about Group I elements.

The alkali metals:

- are …….. – you can cut them with a knife
- are …….. – but only when freshly cut
- quickly …….. in moist air – they react with water and oxygen
- have low …….. – some float on water
- react with water to form …….. and an …….. solution of the metal …….. .

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For example: sodium + water → sodium hydroxide + hydrogen

lithium + …….. → …….. +

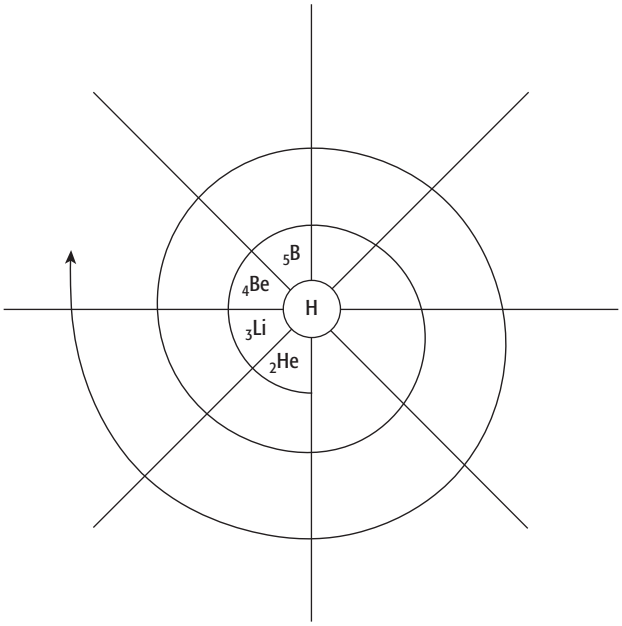
……..

…….. + water → caesium hydroxide + ……..

3 Complete the following table:

Halogen	Symbol	Physical state (at r.t.p.)	Formula of compound with potassium	Electron arrangement
fluorine			KF	
		gas		
bromine				2,8,18,7
	I			2,8,18,18,7

4 The diagram shows a novel spiral form of the Periodic Table. The first five elements are positioned for you.



a Complete this diagram by putting in the symbols and atomic numbers for the elements up to and including the element with atomic number 20.

b Label the segments that correspond to:

i the alkali metals **ii** the noble gases.

c Expand the diagram to suggest how the transition metals could be included.

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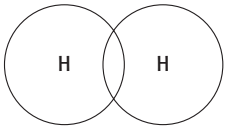
Worksheet 3.3

Chemical bonding

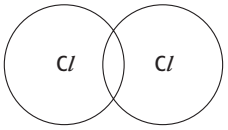
1 Covalent bonding diagrams

In all the following examples, make sure you use suitable symbols to indicate that the electrons come from different atoms.

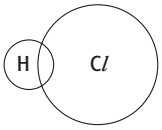
a The following three diagrams can be completed to illustrate how single covalent bonds are formed between non-metal atoms. Draw in all the outer shell electrons in each case to show the bonding in these molecules.



hydrogen molecule (H_2)

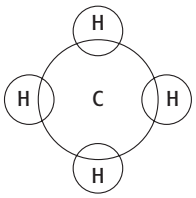


chlorine molecule
(each chlorine is now 2,8,8)

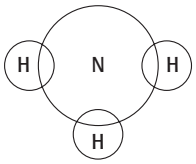


hydrogen chloride

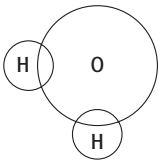
b These are more complex examples of covalently bonded molecules. Complete the diagrams by drawing in the outer shell electrons in each case.



methane molecule



ammonia molecule



water molecule

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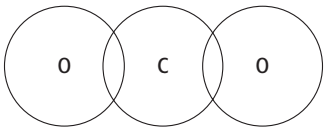
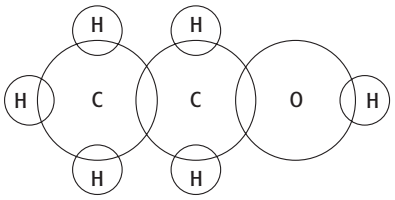
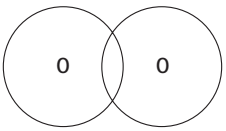
c Finally, here are examples that involve multiple bonding or more than two types of atom. Complete the diagrams showing the bonding as for the earlier examples.



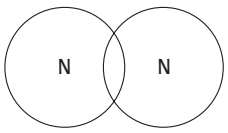
carbon dioxide, CO_2



ethanol, C_2H_5OH



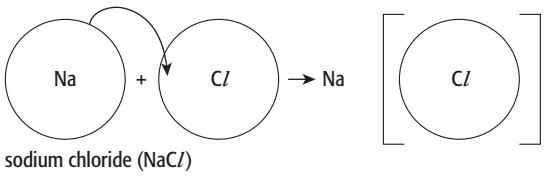
oxygen, O_2



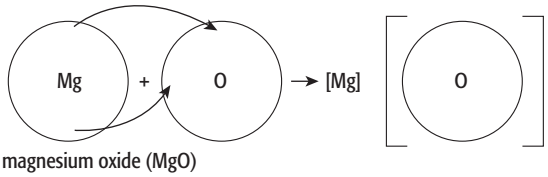
nitrogen, N_2

2 Diagrams showing ionic bonding

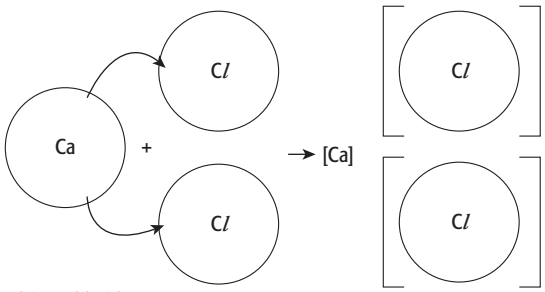
Complete these diagrams by drawing in the electrons and the charges on the ions in each case.



sodium chloride (NaCl)



magnesium oxide (MgO)



calcium chloride ($CaCl_2$)

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Worksheet 3.4

Writing chemical formulae

1 Complete the following tables on the formulae of ionic compounds.

a

Compound	Positive ion	Negative ion	Relative number of ions		Formula of ionic compound
sodium chloride	Na^+	Cl^-	$1 \times Na^+$	$1 \times Cl^-$	NaCl
magnesium bromide	Mg^{2+}	Br^-	$1 \times Mg^{2+}$	$2 \times Br^-$	
aluminium fluoride	Al^{3+}	F^-	..... $\times Al^{3+}$	..... $\times F^-$	AlF_3
potassium oxide	K^+	O^{2-}			
iron(III) oxide	Fe^{3+}	O^{2-}	$2 \times Fe^{3+}$	$3 \times O^{2-}$	

b

Compound	Positive ion	Negative ion	Relative number of ions		Formula of ionic compound
sodium hydroxide	Na^+	OH^-	$1 \times Na^+$	$1 \times OH^-$	NaOH
magnesium nitrate	Mg^{2+}	NO_3^-	$1 \times Mg^{2+}$	$2 \times NO_3^-$	
aluminium hydroxide	Al^{3+}		..... $\times Al^{3+}$	$3 \times$	$Al(OH)_3$
potassium carbonate	K^+	CO_3^{2-}			
iron(II) sulfate	Fe^{2+}	SO_4^{2-}			

2 What are the formulae of the following compounds?

a ammonia .....

b methane .....

c hydrogen peroxide .....

d nitric acid .....

e sulfuric acid .....

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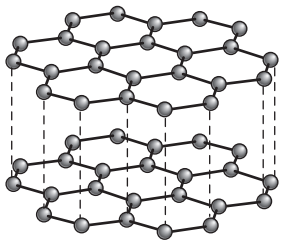
Worksheet 3.5

Bonding and crystal structure

1 Match each of the following substances to the type of structure it has by drawing a line between the boxes.

Substance	Structure
graphite	giant metallic
magnesium oxide	giant molecular
iodine	giant molecular
brass	giant molecular
diamond	giant ionic
silicon dioxide	simple molecular

2 **a** **i** What substance does this structural diagram represent? ……..



ii This structure gives the substance some very distinctive properties. Give **two** of these properties.

……

……

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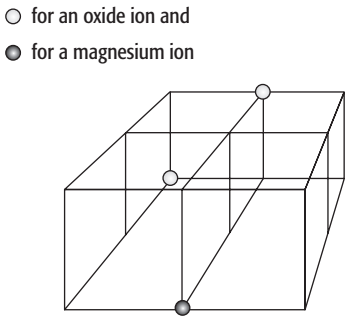
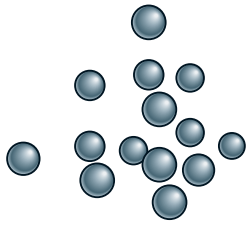
b Complete the magnesium oxide lattice by adding further ions to complete the diagram of the lattice.



c Complete the diamond structure by adding lines to show the covalent bonds between the carbon atoms.



3 Complete the table below by stating:

a the elements present in the compound

b the bonding in the compound.

The first one has been completed for you.

Compound	Type of element	Type of bonding
sodium chloride (NaCl)	sodium metal chlorine non-metal	ionic
ammonia (NH_3)		
calcium oxide (CaO)		
methane (CH_4)		
magnesium nitride (Mg_3N_2)		

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4 Copy and complete these sentences using the words below to fill the gaps.

covalent **giant** **high** **low** **molecules** **strong** **weak**

Although …….. bonds are very strong, the forces between simple covalent molecules are …….. Because of this, substances with small …….. , such as methane or ammonia, have very …….. melting and boiling points.

Some covalent materials, such as diamond or silicon dioxide, form …….. structures. Because every bond in these materials is a …….. covalent bond, they are hard solids with …….. melting and boiling points.

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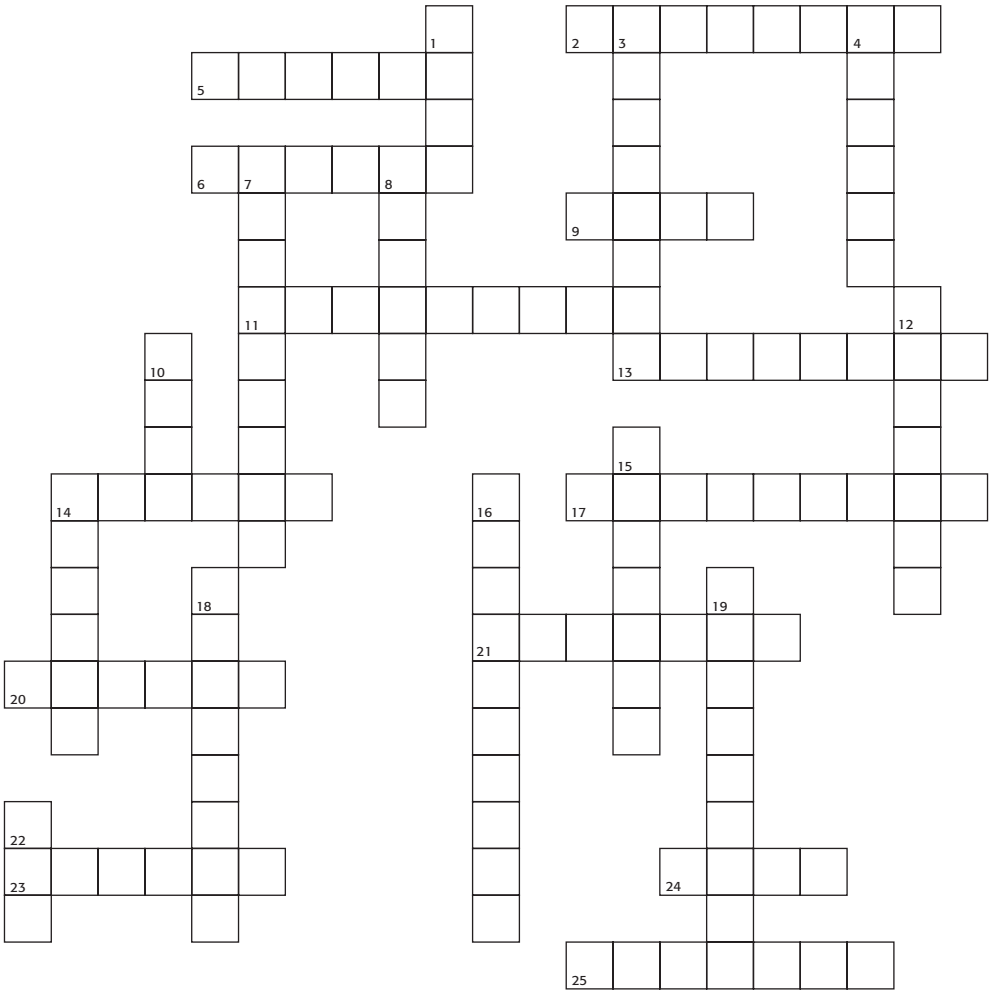
Worksheet 3.6

Periodic Table crossword



CLUES

Across:

2 My relative atomic mass is 35.5.

5 I have 2 electrons in the first shell, 8 in the second shell, and 6 in the third shell.

6 I am the head of the fourth group and am known as the 'basis of life'.

9 My atomic number is 79.

11 I am a transition metal with 25 electrons.

13 I make up 78% of dry air and am the first initial of NPK.

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14 I am a silvery white metal used to make salt.

17 I am a member of the alkaline earth metals and have a great deal of flare!

20 I am a noble gas with 2 electrons and a sunny disposition.

21 I am the second most abundant element in the Earth's crust and have 14 neutrons.

23 I am a member of the halogen family with an atomic number of 53.

24 I am a transition metal with 30 electrons and tend to galvanise things!

25 I am the only element in the halogen family that is a liquid.

Down:

1 The nuclei of my atoms contain 26 protons.

3 I am not really an alkali metal, but since I have only 1 electron I form an X^+ ion.

4 I am a metal with 28 electrons.

7 I am a member of the boron family and am the most abundant metal in the Earth's crust.

8 I am a gas with 8 protons and 8 neutrons and help things burn!

10 I am a member of the carbon family often mistaken for the end of your pencil.

12 I am a metal that is liquid at room temperature – 'quicksilver' is my ancient name.

14 My atomic number is 47 and I am used to make photographic film.

15 I have 20 neutrons and am found in your teeth and bones.

16 I am a member of the nitrogen family with 16 neutrons.

18 I am a gas with a mass number of 19.

19 I am the first element in the fourth period used in making fertiliser.

22 You can find me in the carbon family in the fifth period.

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Worksheet 3.7

Trends in the Periodic Table

The diagram below shows a section of the Periodic Table showing Periods 3 and 4, together with Group IV.

			C				
Na	Mg	Al	Si	P	S	Cl	Ar
K	Ca	Ga	Ge	As	Se	Br	Kr
			Sn				
			Pb				

1 What trend is observed in the nature of the elements across Period 3 (Na to Ar)?

.....

2 Is the same trend observed exactly in Period 4 (K to Kr)?

.....

3 What trend do you observe in descending Group IV (C to Pb)?

.....

4 Which four elements form basic oxides?

.....

5 Which of the elements in Period 3 forms an amphoteric oxide?

.....

6 Which elements do not form oxides at all?

.....

7 Where in the Periodic Table is the most reactive and metallic metal found?

.....

8 Where in the Periodic Table is the most reactive and non-metallic non-metal found?

.....

9 Which is more reactive, calcium (Ca) or magnesium (Mg)?

.....

10 Arsenic oxide dissolves in both acids and alkalis. What does this tell you about arsenic oxide?

.....

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Worksheet 3.8

The Periodic Table of the elements

Part 1

Below are listed 36 elements with their chemical symbols and atomic weights (now referred to as relative atomic masses, A_r).

When chemists first arranged elements in a Periodic Table, they put them in order of their atomic weight starting on the left and filling each row in turn.

1 You should try to do the same. There are 36 spaces for the 36 elements in the grid provided. Write the symbol of the element and its atomic weight in sequence into the boxes in pencil.

Aluminium Al 27	Argon Ar 40	Arsenic As 75	Beryllium Be 9
Boron B 11	Bromine Br 80	Calcium Ca 40	Carbon C 12
Chlorine Cl 35.5	Chromium Cr 52	Cobalt Co 59	Copper Cu 63.5
Fluorine F 19	Gallium Ga 70	Germanium Ge 73	Helium He 4
Hydrogen H 1	Iron Fe 56	Krypton Kr 84	Lithium Li 7
Magnesium Mg 24	Manganese Mn 55	Neon Ne 20	Nickel Ni 59
Nitrogen N 14	Oxygen O 16	Phosphorus P 31	Potassium K 39
Scandium Sc 45	Selenium Se 79	Silicon Si 28	Sodium Na 23
Sulfur S 32	Titanium Ti 48	Vanadium V 51	Zinc Zn 65

Now look at a modern Periodic Table. Have you made any mistakes? Correct them and go over your work in ink.

Draw in a line dividing the metals from the non-metals.

2 Consider the position of hydrogen in the table. Give **one** reason why it could be placed in Group I as this table suggests, and **one** reason why not.

.....

.....

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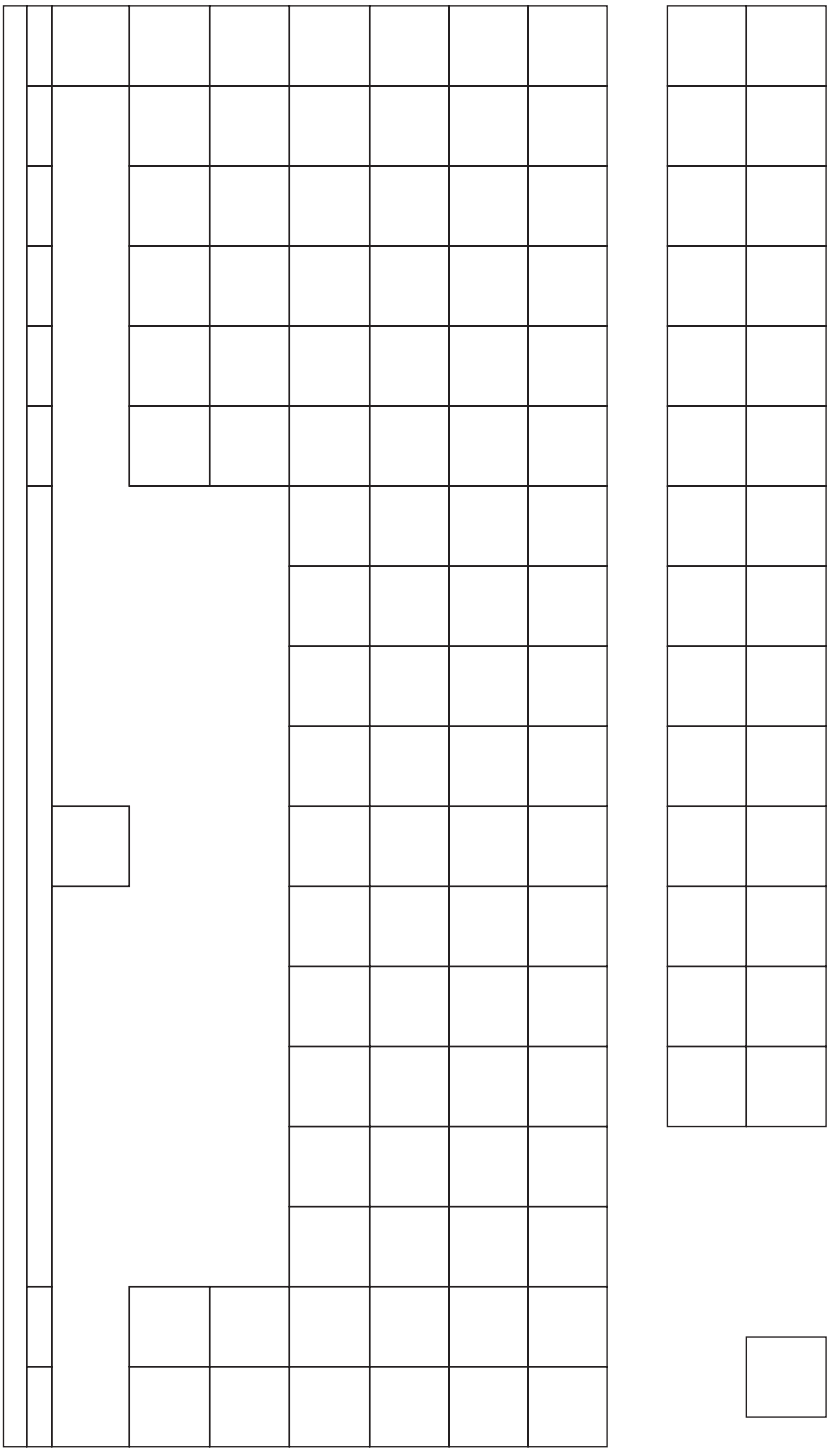

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Part 2

Below are the first 36 elements in the periodic table with their atomic numbers, as seen in Part **1**.

I	II											III	IV	V	VI	VII	0
								H 1									He 2
Li 3	Be 4											B 5	C 6	N 7	O 8	F 9	Ne 10
Na 11	Mg 12											Al 13	Si 14	P 15	S 16	Cl 17	Ar 18
K 19	Ca 20	Sc 21	Ti 22	V 23	Cr 24	Mn 25	Fe 26	Co 27	Ni 28	Cu 29	Zn 30	Ga 31	Ge 32	As 33	Se 34	Br 35	Kr 36

1 Give the symbol for **one** example of each of the following:

a a metal

b a gas

c a transition element

2 Find Cl (chlorine) in the table above.

a What is the group number?

b Which period is it in?

c How many electron shells does it have?

d How many electrons are there in its outer shell?

3 Explain what is meant by '**atomic number**'.

.....

.....

4 **a** What name is given to the elements in Group 0?

b When Mendeleev was drawing up his first suggestions for the Periodic Table, these elements had not yet been discovered. Suggest a reason for this.

.....

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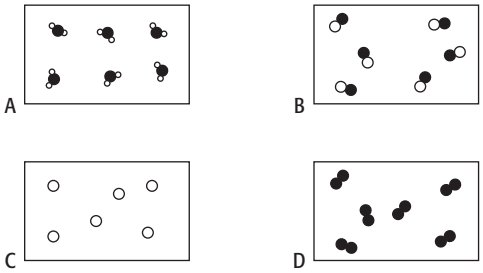
Worksheet 3.9

Noble and inert!

The boxes below represent the particles of different gases. One box shows the particles of elements in Group 0 (Group VIII).



1 **a** What name is given to Group 0 (8) elements? ……..

b Name **two** elements from Group 0. ……..

2 **a** Which box best represents particles from Group 0 elements? ……..

b Explain the reason for your answer.

……

……

3 A lighted splint is put into a gas jar of helium. What would happen?

……

4 Some properties of elements change as you go down their group in the periodic table. Research the library or the internet and, for each property listed below, comment on whether it changes as you go down Group 0 and, if so, how it changes.

a Reactivity:

……

……

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